M* 16.21

THE DESCRIPTION and USE OF AN INSTRUMENT, Called the DOUBLE SCALE OF PROPORTION.

By which Instrument, all Questions in

Arithmetick,
Geometry,
Trigonometry,
Astronomy,
Geography,
Navigation,
Fortification,
Gunnery,
Gaging Vessels,
Dialling,

BIBL. CANT. ACAD.

May be most accurately and speedily performed, without the assistance of either Pen or Compasses.

By SETH PARTRIDGE.

LONDON,
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1815.99

TO
The Right Worſhipfull, Sir RICHARD COMBE, Knight.

The Authour preſents theſe, with his other beſt Services.

SIR,

THe Tranſcendency of your Knowledge in all Noble and Learned Sciences, hath heightened my ambition preſumptuouſly to affix on you this Dedication, and to this boldneſſe its your Love and Favour that invites me, and prevents me too of all Apologies for my thus doing. For truly I ſhould not ſo boldly have adventured to ſhroud this unworthy Piece under the wings of your worthy Patronage, were I not aſſured that as in Judgment you are able to diſcern of it; ſo in your noble diſpoſition willing favourably to accept it. The poor Widows two mites being the utmoſt of her ability, was accepted of by him, who was greater than the greateſt of Mortals, far above the great gifts of the Rich; which

imboldens me (without doubt of obtaining) humbly to desire your Worship, to vouchsafe me both pardon for my presumption, and acceptance of my little mite, which having obtained, I shall think my self and Work, to have a sufficient protection against all Cynical and ill-affected Detractors, a thing which all mens Works (how excellent soever) are subject unto, (much more mine) and therefore into the wide Ocean I dare not commit my weak Vessel, without some able Pilot, such as your Noble Self, whose sound Judgement and great Learning is so well known, that your Name prefixt before my Book, will be not onely a defence against the carping of Zoylists, *but also to beget a good affection in the Readers. Not to trouble your Worship more with words, my hope is, that this my boldnesse will be imputed to a will, rather to do you service than otherwise, might your Worship be pleased thereof so to make construction, I have attained my desired end, who am*

Your Worships

ever to serve you,

Seth Partridge.

To the Reader.

Friendly Readers,

YOu have here presented to your view those most Excellent Scales, or Lines of Numbers, Sines, and Tangents doubled, by means of the moving whereof, the use of Compasses is wholly avoided, and the Question resolved, by applying the Scales one to another. Some men (I know) have laid aside the using of the single Scales, because with an ordinary pair of Compasses on a large Scale, they could not work many examples they desired. But by these double Scales, how large soever, he shall never be troubled with any Compasses, nor the work never to out-run the Scale. And besides, upon the Instrument may be inserted any other Scales or Lines, as are for measuration, or otherwise, such as each mans Calling and Occasions do most require, and so make the Instrument of general use.

To plead for my Book, I will not, the Subject whereon it treats, will do that better than I can; I am sure here is a good Subject, a good piece of Cloath, if the Garment be not marred in the making; if it be, the fault is in the botching Taylor, not

in the ſtuffe. The Ingenious (I know) will wink at faults for they know themſelves ſubject to them, and faults declare men to be but men. As for Curioſity in the method, here is none, nor was any intended, my diſhes being dreſt, not as at a Feaſt, but as at an Ordinary, nor placed in ſo methodicall an order as they might have been, I taking things not orderly, but at an adventure, and as it happened to come into mind: I know my Subject, nor method, will pleaſe all, yet I doubt not, but it will pleaſe ſome. What the Ignorant ſay of it, I care not, they are like the Fox, that deſpiſed the grapes, becauſe they grew ſo high he could not reach them. And what the ſpiteful ſpeak of it, I paſſe not, they are like the filthy Fly, that ſeeks all over the body for a ſore, and when it cannot find one, it makes one. It is the cenſure of the impartial, judicious and ſolid Judgment which I reſpect, to whom I will ſtand, and to which onely I will ſubmit, reſting Servant to all ſuch, while I am

Seth Partridge.

An Advertiſement.

HEre *might have been expected the* Print *of the* Rule, *but in regard of its ſliding it could not be well demonſtrated: Wherefore I thought good to Advertiſe, that this* Scale *and all other* Mathematical Inſtruments, *are accurately made by Mr.* Walter Hayes *at the* Croſs-Daggers *in* More-Fields, *next Door to the* Popes-Head-Tavern, London: *Where they may be furniſhed with Books to ſhew the Uſe of them: As alſo with all ſorts of* Maps, Globes, Sea-Platts, *and* Mathematical Paper, Carpenters Rules, Poſt *and* Pocket Dials *for any Latitude, at Reaſonable Rates.*

THE *Double Scale of Proportion.*

The Deſcription and Uſe of an Inſtrument conſiſting of *Doubled Scales.*

Whereby all Concluſions Mathematical may be performed onely by Application of Scales.

CHAP. I.

The Inſtrument deſcribed.

THe Inſtrument whereof I treat in this Book, I call the *Double Scale*, for that the Scales, or Lines thereupon, are doubled; ſo and in ſuch manner, that by applying the one to the other, they will of themſelves reſolve any queſtion Mathematical, that may be done by the Pen, or by Tables of Sines, Tangents, and Logarithms. The Scales principally inſcribed thereupon, are thoſe moſt admi-

admirable Lines of Numbers, of Sines, and of Tangents, whose use hath been heretofore set forth, onely to be wrought upon with a pair of Compasses, and no otherwise. But I have so contrived them double, upon an Instrument to move, or slide along one by the other, in such manner, that upon the same, without any assistance of Compasses, I can work all Conclusions Mathematical, that can be wrought by the single Lines, with the help of Compasses, both in *Arithmetick*, *Geometry*, *Trigonometry*, *Astronomy*, *Geography*, *Navigation*, *Gaging of Vessels*, *Fortification*, *Gunnery*, *Dialling*. Yea, and the Usurer too, may hereby also compute the true interest of his money. In all which, I I shall give you some examples for your instruction, in the use of my Double Scale.

The body, or matter whereof the Instrument is made, may be either of Brasse, or of very good and well seasoned Box. It consisteth of three pieces, or Rulers, each one about half an inch in breadth, and about a quarter of an inch in thicknesse, more or lesse, as the Maker and User of them pleaseth; and for their length, they may be made to what length you will, either one foot, two foot, three foot, or more or lesse, for they are not limited to any length, onely the longer they are, the larger and more will be the divisions of the Scales,

and

and so consequently the more exact in operation. These three Rulers, or pieces of this *Scale*, are to be all of one even length and thickness, and by the edges so evenly joynted, that they may justly slide along close one by the other, having at each end a little plate of Brasse, or Wood fitted to hold them close together, and so fastened to the two out-side pieces, that they may be kept steady, and the middle Ruler to slide to and fro between them.

The Lines, or Scales ingraven on this Instrument, are the ordinary lines of Numbers, of Sines, and of Tangents, onely they are set on double, that is, once upon one Ruler, and once upon the other, upon one and the same joynt; as the line of Numbers is set both upon one of the out-side pieces, and on the middle piece, that is, on both sides the joynt, and numbered on both, and so set to the very edges of both Rulers, that both lines being joyned together, may appear to be but as one line of Numbers, and this line of Numbers is (as it were) twice repeated, or doubled in the length of the Ruler, that is, beginning with 1 at one end of the Ruler, which I call the lower end, and continued to 1 or 10 at the middle, and from thence begin again, and continued to 10 or 100 at the upper end. Also upon the other side of the Rulers, upon the same joynt, is in like

like manner set a like line of Numbers, and this line of Numbers is fittest to be used with the line of Tangents, as that on the other side is with the lines of Sines, without any turning of the Instrument. But you may omit on the line of Numbers upon one side, only observing to turn the Instrument, when the work requireth to be done on several lines, as in the sequel it will appear.

The *Scales*, or Lines of *Sines*, are in like manner set on twice, that is, once upon the other edge of the middle piece, and also on the in-side of the other out-side piece, and they are to be set on, upon both sides the joynt, that they may appear as one line of *Sines*, being laid close together, and numbers set to the Divisions on both parts, and is in the lines of Numbers.

The lines of Tangents is set upon the other side of the Rulers, opposite to the lines of Sines upon the same joynt with them, and likewise so set upon both parts of the Instrument, that the parts being laid close together, the line may appear to be both as one line of Tangents, and numbered on both parts to 45 at the upper end, against 90 on the lines of *Sines*, and from 45 back again to 89 at the lower end, as is usually done in the lines of Tangents.

This Instrument having those *Scales*, or (as it

it pleaſed their firſt Inventor to call them) *Lines*, thus ingraven or ſet on it, will work all concluſions, as may be wrought by Mr. *Gunters* Lines, or Mr. *Wingates*, by onely applying the Lines one to another, without the uſe of Compaſſes, which muſt be alwayes had and uſed with theirs; yet you may uſe Compaſſes with theſe Scales, if you pleaſe, and ſo try and examine your work by both ways, and when you have made ſuch trial, uſe which way you like beſt, and that (for ought I know) may be my Double Scales.

To ſhew the making of the *Scales* of *Numbers*, *Sines* and *Tangents*, is a thing altogether needleſs, the making of them being already ſo ſufficiently ſet forth by others, that for me to do it again, were but labour loſt, both to me in writing, and to the Reader in reading. And thoſe that are makers of Mathematical Inſtruments, do already well underſtand the making of them, and for a man to make one for his own uſe, is but vain, for that he may buy one at a cheaper rate than make it, I ſhall therefore proceed to the uſe: Wherein note, that for diſtinction of the ſides of the Scales, or Lines on the Rulers, *I* uſe the Termes of *Firſt* and *Second*, as being as proper for the purpoſe as any other could have been: For evermore, that ſide of any Line, whereon the firſt term

in

in the rule of Proportion is taken, I call the first side; and the other side of the Line, whereon the second term in the Rule is taken, I call the second side. And then for the third term in the Rule, it is alwayes taken on the same side that the first term is taken on: and for the fourth term, which is the term sought, it is evermore found on that same second side, whereon the second term is taken. As if the first term be taken on any Scale, upon the out-side Ruler, then the second term is on the middle Ruler, and if the first term be taken on the middle Ruler, then the second term is on the same Scale upon an out-side Ruler: And when the work is by several Lines, then the two out-side Rulers both bear the name of *First*, or *Second*.

Other Scales may be added to this Instrument, and set on the sides and edges thereof, as a Scale of equal parts, or a Line of inches, a Meridian-line, a Gage-line, a line of Chords, the lines of Board and Timber-measure, or any others, such as your Calling and Occasions have most use for.

CHAP.

CHAP. II.

The Use and Application of the double Scale of Numbers upon the Instrument, in the principal Rules of Arithmetick.

PROBLEM. I.

Of Multiplication.

Two Numbers being given to be multiplyed together, to find their Product, by the double lines.

IN Multiplication the Analogie is this; As 1 is to one of the numbers given, to be multiplyed together: So is the other of them, to the Product.

Wherefore it may be said, As 1 is to the Multiplicator; So is the Multiplicand to the Product. Or,

As 1 is to the Multiplicand; So is the Multiplicator to the Product.

When two numbers are to be multiplied together, the greater of them is usually counted for Multiplicand, and the lesser for Multiplicator.

To multiply two numbers by the double lines, the manner of working is thus: Place 1 on the firſt ſide, to the Multiplicator on the ſecond ſide: And then againſt the Multiplicand on the firſt ſide, is the Product on the ſecond ſide.

Or elſe, place 1 on the firſt, to the Multiplicand on the ſecond, and then right againſt the Multiplicator found on the firſt, is the Product on the ſecond.

Example 1. Let 8 and 4 be two numbers given to be multiplied together, to find their Product, do thus: upon any one of the ſides, look out 1. (This ſide whereon I take the 1, I call the firſt ſide) I ſet this 1 to 4 on the other ſide (which I call the ſecond ſide,) and then right againſt 8 on the ſame firſt ſide, whereon I did take 1; is 32 on the ſecond ſide, whereon the 4 was taken: This 32 is the Product of 8 multiplied by 4, the thing required.

Or otherwiſe thus.

Set 1 on the firſt, to 8 on the ſecond, and then right againſt 4 on that firſt, is 23 on the ſecond, as before.

Example 2. Let 25 be a Multiplicator, and 30 the Multiplicand, and the Product of them multiplied together, required.

Set 1 on the firſt, to 25 on the ſecond, and then right againſt 30 on the firſt, is 750 on the

ſecond

second. This 750 is the Product of 30 multiplied by 25, the thing required. In like manner, If you set 1 to 30, then against 25 taken on the same side the 1 was, is 730 on the other side whereon the 30 is.

Example 3. Let 45 and 25 be two numbers given to be multiplied together, and their Product required. To resolve this by the double lines, set 1 on the first, to 25 on the second; and against the other number given 45 on the first, is 1125 on the second. This 1125 is the Product of 45, multiplied by 25, which was desired. Or,

Set 1 on the first, to 45 on the second, and then right against 25 on the first, is 1125 on the second, as before.

Example 4. Let $8\frac{75}{100}$ be given to be multiplied by $6\frac{45}{100}$. To perform this work, set 1 on the first, to $6\frac{45}{100}$ on the second, and then against $8\frac{75}{100}$ found on the same side that the 1 is on, is $56\frac{43}{100}$ and something more: therefore $56\frac{43}{100}$ is the Product of $8\frac{75}{100}$, multiplied by $6\frac{45}{100}$, the thing sought.

Or thus, Set 1 or 10 at the upper end of the line on the first, to $8\frac{75}{100}$ on the second, and then against $6\frac{45}{100}$ on the first, is $56\frac{43}{100}$ on the second, as before. The like practice is to be observed in multiplying any other numbers.

Note, that in working by the double lines,

it will be all one, whether you work from 1 at the beginning of the line upwards, or from 10, at the upper end of the lines downwards, As if you set 10 at the upper end on the first, to 4 on the second, and then against 8 on that first, you shall have 32 on the second.

How to square any number, or to multiply a number by it self, as also to cube any number.

Set 1 on the first, to the number to be squared on the second, and then against that given number on the first, is its square on the second. As if 12 be a number to be squared, then set 1 on the first, to 12 on the second, and then against 12 on the same first, is 144 on the second. Therefore 144 is the square of 12. And then again, against 144 on the first, is 1728 on the second, which is the Cube of 12.

PROBLEM II.

Of Division,

Any number being given, to be divided by another number, to find the Quotient.

IN Division, the Analogie is thus:
As the Divisor, is to an Unite:
So is the Dividend, to the Quotient.
Wherefore the work by the double lines is thus,

thus; Look out the Diviſor on the firſt, and ſet it to 1 on the ſecond, and then right againſt the Dividend on the firſt, is the Quotient on the ſecond.

Example 1. Let 273 be a number given to be divided by 13. Look 13 the Diviſor on any one ſide, which we call the firſt ſide, and ſet it to 1 on the ſecond ſide. And then right againſt the Dividend 273 upon that firſt, is 21 on the ſecond. Wherefore 21 is the Quotient of 273 divided by 13, which was required.

Example 2. Again, if 1728 be given to be divided by 12, then ſet 12 the Diviſor on the firſt, to 1 on the ſecond; and when that is done you ſhall right againſt 1728, the Dividend on that firſt, ſet 144 on the ſecond, which 144 is the Quotient of 1728, divided by 12, and ſo of any other.

In Diviſion note this, that ſo many times as the Diviſor may be placed under the Dividend, ſo many places of figures ſhall be in the Quotient. As if 34785, be to be divided by 75, the Quotient ſhall conſiſt of three figures onely, and no more; becauſe 75 can be placed onely three times under 34785: And under 1728 the Dividend given, the Diviſor 12 can three times be placed, and therefore three figures in the Quotient. And if you will divide 144 by 12, then ſet 12 on the firſt, to 1

on the second; which done; against 144 on the first, you have 12 on the second.

Example 3. Let $46\frac{75}{100}$ be given, to be divided by $8\frac{5}{12}$, and the quotient required. In this case, as in all other: Set the Divisor $8\frac{5}{12}$ on the first, to 1 on the second, and then against the Dividend $56\frac{75}{100}$ on that first, is $5\frac{5}{12}$ on the second: therefore $5\frac{5}{12}$ is the quotient required, very speedily and exactly found.

PROBLEM III.

Of Reduction of Fractions.

To reduce any vulgar Fraction into a decimal Fraction.

LEt $\frac{5}{12}$ be a vulgar Fraction propounded, to be reduced into a decimal Fraction. Now it is to be noted, that vulgar Fractions are reduced into decimals by the rule of proportion, in this manner:

As the Denominator of the Fraction given,
Is to the Numerator thereof:
So is an Unite with cyphers, one, two, or three
To a new Numerator, which Numerator will have so many places of figures in it, as the new Denominator hath cyphers, and therefore the Fraction given is thus reduced into a Decimal. As

As the Denominator 84, Is to the Numerator 63.

So an Unite with two cyphers, thus 100, to 75, which 75 is the new Numerator to that new Denominator 100. Therefore $\frac{75}{100}$ is a decimall Fraction, equal in value to $\frac{63}{84}$. To work this kind of reduction by the double lines, do thus.

Set 84 (the Denominator of the vulgar fraction given) on the firſt, to 1 on the ſecond, & then right againſt 63, the Numerator on the firſt, is 75 on the ſecond, which 75 is the new Numerator of a decimal Fraction, whoſe Denominator is an Unite with two cyphers. Thus is $\frac{63}{84}$ changed into $\frac{75}{100}$, which new Fraction is equal in value with the former.

Again, if $8\frac{12}{100}$ be a number given to be reduced into a decimal; ſet 40, the Denominator of the fractional part, to 1, and then right againſt 12, on that part as you took the 40, is 2 on that ſecond ſide whereon the one was, and ſo the Fraction is become $\frac{3}{100}$, which joyned to the 8, makes the mixt number that before was $8\frac{12}{100}$, to be $8\frac{3}{100}$, and of equal value.

Note that the point 1 repreſenteth alſo 10, 100, or 1000, and therefore the new Denominator may be taken either, 10, or 100, or 1000, as in your own judgement it ſhall ſeem moſt fitting. As here in this laſt Example, we

found 3 to stand right against 12½ and therefore we put but one cypher to the unite, and made the Fraction $\frac{3}{10}$. And in the last Example before, we found 75 to be against the 63, which because it consisteth of two places of Figures, we put two cyphers to the unite for Denominator of the new Fraction, and so made it $\frac{75}{100}$, and so of all other.

Also be it remembred, throughout the residue of this work, that all Fraction figures are set right in the line, like whole numbers, without any Denominator under them, being separated or distinguished from the whole part of that number by a Comma, as all such Fractions as these $46\frac{75}{100}$, $6\frac{45}{100}$, $8\frac{5}{10}$, and $5\frac{5}{10}$, are thus expressed 46,75. 6,45. 8,5. and 5,5. which manner of writing Fractions being well observed, is a readier way than that other, of one number above, and another below, with a line between. Also note, That the Fractions so expressed are all Decimal Fractions, whose Denominator is a Unite with so many Cyphers as there be Fraction figures, as the Denominator of the Fraction Figures of the 75 belonging to the whole number 46 is 100, being a unite with two cyphers, because two figures and the Denominator to 5 is 10, being a unite with one cypher, because but one figure. And when a Fraction is to be expressed alone without a whole

whole number, then the Numerator is first expressed, and after it the Denominator right on in the line, with a Comma betwixt, as $\frac{75}{100}$, and $\frac{5}{10}$, are thus expressed 75,100. 5,10. and so of other the like.

PROBLEM. IV.

Of Continual Proportionals.

Two numbers being given, to find a third, a fourth, a fifth (or many numbers) in continual proportion Geometrical to them two.

Example. LEt the two numbers given be 2 and 4, and it be required to find several numbers in continual Geometrical proportion to them two.

Set 2 on the first, to 4 on the second, and then against 4 on that first, is 8 on the second, which is the third number in continual proportion Geometrical to them two; and then against 8 on the first, is 16 on the second, which 16 is the fourth number in continual proportion to them two; and against 16 on the first, is 32 on the second, the fifth continual proportional; and against 32 on the first, is 64 on the second, the sixth continual proportional; and against 64 on the first, is 128 on the second, the seventh continuall proportional; and against

againſt 128 on the firſt, is 256 on the ſecond which is the eighth proportional to the two propoſed numbers. Wherefore 8, 16, 32, 64, 128, and 256, are a rank of numbers in continual Geometricall proportion, to 2, and 4, the thing that was required.

Example 2. Let it be required to find a rank of numbers in continual proportion, as 2 to 3. Here ſet 2 on the firſt to 3 on the ſecond, and then without moving the Inſtrument, againſt 3 on the firſt, you have 4,5 on the ſecond, and againſt the ſame 4,5, found on the firſt, is 6,75 on the ſecond; and againſt 6,75 on the firſt, is 10, 125 on the ſecond. Therefore 4, 5, 6,75, and 10, 125, are a rank of numbers in continual proportion to 2 and 3, as is required.

If it be required, to find ſuch a rank of proportionals to the numbers 2 and 4, which may bear the ſame proportion to one another, as 2 bears to 4: Set 4 to 2, and then againſt 2 on that firſt ſide whereon the 4 is, you have 1 on the ſecond ſide, which is the third proportional to 4 and 2, bearing the ſame proportion to 2, as 2 doth to 4. And againſt 1 on the firſt, is 5, 10 on the ſecond, the fourth proportional; and againſt 5, 10 on the firſt, is 25, 100 on the ſecond, which is the fifth number in continual proportion inverſe, or backward.

If the two numbers given be 10 and 9, and a rank

rank of Numbers to them in an inverſe proportion Geometrical be required; ſet 10 on the firſt, to 9 on the ſecond, and then againſt 9 on the firſt, is 8, 1 on the ſecond, which is the third proportional; and then againſt 8, 1 is 7,29 the fourth proportional: whereof 10, 9 8, 1 and 7,29 are numbers in a continual proportion. But if the numbers given be 1 and 9, and a third and fourth numbers in proportion to them, as 9 is to 1, be required, then muſt the numbers found be accounted 81 and 729, they being the third and fourth numbers in a Geometrical proportion to 1 and 9. In like manner, if the two numbers given be 10 and 12, then if you ſet 10 to 12, you ſhall ſee on the firſt againſt 12, 14,4; which is the third proportional: and againſt 14, 4 on the firſt, is 17,28 on the ſecond, which is the fourth proportional, But had the two numbers given been 1 and 12, then bring 1 on the firſt, to 12 on the ſecond, and you ſhall have againſt 12 on the firſt, 144 on the ſecond, for the third proportional, and the fourth will be 1728, and ſo of all other.

PROBLEM

PROBLEM V.

Of the Rule of Proportion direct.

Three numbers being given, to find a fourth, the Analogie ſtandeth thus.

AS the firſt number is to the ſecond,
So is the third number, to a fourth.

Therefore work thus: Set the firſt number in the proportion on the firſt ſide, to the ſecond number in the proportion on the ſecond ſide: And then againſt the third number on the firſt, is the fourth number ſought for on the the ſecond.

Example 1. Let the Diameter of a known circle be 7, and its circumference 22, and it be required to know what the circumference of another circle is, whoſe Diameter is 14. To reſolve this *quære*: Set 7 on the firſt to 22 on the ſecond, and then againſt 14, the Diameter of the other circle found on the firſt, is 44 on the ſecond: This 44 is the circumference of that other circle, whoſe Diameter is 14.

Example 2, If 45 yards of Stuff coſt 30 pound, what will 84 yards of it coſt?

Set 45 (the firſt number in the Rule) on the

firſt,

first, to 30 (the second number) on the second; and then against 84 (the third number in the Rule) on the first, is 56 on the second, which 56 is the fourth number, and sheweth that 84 yards will cost 56 pounds. Or,

If 45 acres of land be worth 30 pounds a year, what will 84 acres be worth by the year The answer is as before 56 pounds.

And if 26 of any thing give, 64, what will 36 of the same give? Set 26, to 64, and then against 36 on the first, is 88, 615 the answer to the question demanded on the second.

Note, that generally in the Rule of direct proportion; If the third number be greater than the first, then will the fourth number be greater than the second. But if the third number be lesse than the first, then the fourth number will be lesse than the second.

Example 3. If the circumference of a circle be 22, and its Diameter 7, what will the Diameter of another circle, whose circumference is 44?

Here set 22 on the first, to 7 on the second, and then against 44 on the first, is 14 on the second, which 14 is the Diameter of that circle, whose circumference is 44, be their measures taken in inches, feet; or any other measure whatsoever.

To make proof of the work, whether truly wrought,

wrought, or not. Multiply the first term in the Rule, and the fourth term newly found, the one by the other, and likewise the second and third terms; and if the two Products be equal, the work is truly wrought, or else not.

To prove the last question by the lines; Set 1 on the first, to 22 on the second, and then against 14 on the first, is 308 on the second: Next, set 1 to 7, and then against 44 on that first, is 308 on the second, here both Products being equal, proves the work to be truly wrought.

PROBLEM VI.

The Rule of Proportion Inverse.

Three numbers being given, to find a fourth in an Inversed Proportion.

IT is to be noted, in this Inverse Rule of Proportion, that if the third number be greater than the first, then will the fourth number be lesse than the second. And contrariwise, if the third number be lesse than the first, then the fourth number is to be greater than the second.

But in the Rule of Proportion direct; If the second number, or term, be more than the first,

first, then the fourth term is also more than the third. And if the second term be lesse than the first, then is the fourth term lesse than the third.

This Inverse Rule may be wrought two wayes on our double lines. One way is thus: Set the first term, on the first, to the other term of the same denomination on the second: And then against the other term of contrary denomination, sought out on that second, is the fourth number sought for, on the first; Or else, set the third term on the first, to the first term on the second, and then against the second term on the first, is the answer on the second.

Example 1. If 60 Pioners can make a trench in 45 hours; In how long time can 40 Pioners make it?

Set 40 on the first, to 60 on the second (the two numbers of the same denomination:) and then against 45 on that first (the number of contrary denomination) is 67,5 on the second, which 67,5 is the fourth term in reciprocal proportion to the other three, and of the same denomination with 45, *viz.* hours, and is the answer to the question demanded, shewing that 40 men can do as much in 67,5 hours, as 60 men can do in 45 hours. Or set 68 on the first, to 40 on the second, and then against

againſt 45 on that ſecond, is 67, 5 on the firſt.

Another way is thus: Set 40 the third term, on the firſt, to 45 on the ſecond, (which is the term of contrary denomination to the other two) and then right againſt 60, on the firſt, (which is the number of the ſame denomination with the 40) is 67, 5 on the ſecond, the number ſought. Thus one way of working proves the other.

Example 2. If 45 men do a work in 30 dayes: In how many dayes will 270 men do it?

Set 270 on the firſt, to 45 on the ſecond, and then againſt 30 on the firſt, is 5 on the ſecond. Or,

Set 270 on the firſt, to 30 on the ſecond, and then againſt 45 on the firſt, is 5 on the ſecond: And therefore the fourth number ſought for is 5, ſhewing that 270 men will do as much work in 5 dayes, as 45 men can do in 30 dayes.

This Rule is proved by multiplying together the firſt and ſecond terms, and alſo the third and fourth: And if the two Products be equal, the work is truly wrought, or elſe not.

By the lines it is thus proved: Set 1 on the firſt, to 30 on the ſecond, and then againſt 45 on the firſt, is 1350 on the ſecond. This done Set 1 on the firſt, to 5 on the ſecond, and then

againſt

againſt 270 on the firſt, is 1650 on the ſecond; here both Products being equal, declareth the work to be truly wrought.

PROBLEM VII.

Of Duplicated Proportion.

Three numbers being given, to find the fourth in a Duplicate Proportion.

THis Rule chiefly concerns the proportion of Lines to Superficies, or of Superficies to Lines.

I *Of the Proportion of Lines to Superficies.*

Example 1. If the diameter of a circle be 14 inches, and its Content 154 inches; What will the Content be of another circle, that is 28 inches in diameter?

Set 14 on the firſt, to 28 on the ſecond, (they being the terms of one denomination, *viz.* Lines) and then againſt 154 on the firſt, (the content of the circle given) is 308 on the ſecond: This 308 ſeek on the firſt, and againſt it on the ſecond is 616, which 616 is the content of that other circle of 28 inches diameter.

Example 2. Let the diameter of one circle be 7 foot, and the Area of it 38,5 foot, and let it be demanded, What the ſuperficial Area of another cirrcle is whoſe diameter is 18 foot?

Because 7 and 18 be terms of one denomination, *viz.* Lines; Set 7, (the diameter of the the circle, whose Content is known) on the first, to 18 on the second, being the diameter of the other circle, whose Content is sought, and then against 38, 5 (the Content known) on the first, is *99* on the second, and then seek this *99* on the first, and against it is 254, 5 tenths on the second, which is the superficial Area, or Content in feet of that other circle which was demanded.

Example 3. If a peece of land that is 20 pole square be worth 30 pounds; What is a peece of land of the same goodnesse worth, that is 35 pole square?

Set 20 on the first, to 35 on the second, and then against 30 on the first, is 52, 5 on the second; and lastly, against 52, 5 on the first, is 91, 8 on the second: that is 91 pounds, and eight tenths of a pound, or 16 shillings. So much is the worth of that piece of land of 35 pole square.

Example 4. How many acres of land of our English measure of 16,5 foot to the people, are contained in 30 Irish acres, of 21 foot to the pole.

Place 16,5 on the first to 21 on the second, and then against 30 on the first, is 38, 2 on the second; and against 38, 2 on the first, is 48,6

on

on the second. So many English acres are in 30 Irish acres.

2 *Of the Proportion of Superficies to Lines.*

If the two terms of like denomination be of superficial Contents, and a diameter, or a line sought for.

Example. Let two circles be given, the Content of the one being 154, and its diameter 14. the Area of the other circle is 616, and its diameter is required.

Set the Area of the circle known, *viz.* 154 on the first, to its diameter 14 on the second, and then against 616 on the first, is 56 on the second. The half whereof, *viz.* 28, is the diameter of that other circle, whose Content is 616, which 28 is feet, or inches, or any other measure, such as the diameter of the other circle was measured by.

PROBLEM VIII.

Of Triplicate Proportion.

Three numbers being given, to find a fourth, in a Triplicated Proportion.

THis Rule concerneth the proportion betwixt Lines and Solids. *Example* 1. There is a Bullet whose diameter is 4 inches, weigheth 9 pounds: What will another Bullet

weigh, whose diameter is 8 inches, and of the same metal.

Set 4 on the first, to 8 on the second, (that is the one diameter to the other:) And then against 9 on the first, (which is the weight of the Bullet of 4 inches diameter) is 18 on the second, and against 18 on the first, is 36 on the second; and thirdly, against 36 on the first, is 72 on the second. This third summe found, is the fourth proportional number, which was required, shewing that the weight of that other Bullet of 8 inches diameter, is 72 pounds.

Example 2. If a Gun of 5 inches diameter, require for her due charge 16 pound of powder; How much powder will a Gun of 4 inches diameter in the bore require, for her due charge, of the same powder?

Place 5 on the first, to 4 on the second, and then against 16 on that first, is 12,8 on the second; and next against 12, 8 on the first, is 10, 24 on the second; and thirdly, against that 10,24 on the first, is 8, 2 on the second, which third number 8,2 is the answer to the question: shewing that 8 pounds, and 2 tenth parts of a pound of powder, is a due charge for a Gun of 4 inches bore.

PRO-

PROBLEM IX.

A Company of men laying down several sums of money together into one stock, wherewith they trade and get gain; to find out how much each mans part of the gain must be, answerable to his part of money laid down in stock.

LEt five men, whose names let be represented by these five letters, A, B, C, D, E, make a stock of 300 pounds, of which stock A put in 84 pounds, B put in 72 pounds, C put in 48 pounds, D put in 54 pounds, and E put in 42 pounds, which all together make the 300 pounds. Now at the end of a time, having traded therewith, they gained clearly 50 pounds: And let it be demanded, what portion of the gain each man must have, according to his proportion of mony laid down in stock.

The Rule to answer this demand is thus:

As 300, the whole stock, To 50 pounds the whole gain;

So is each mans portion of the stock, To his portion of the gain.

Therefore,

Set 300, the stock on the first, to 50 the gain on the second; and then against each mans particular portion laid down, being sought out on the first, is his portion of the gain on the

ſecond. As againſt 84, the portion laid down by A on the firſt, is 14, his portion of the gain on the ſecond; and againſt 72, the portion of B, is 12 pounds, his portion of the gain; againſt 48. the portion of C. is 8 pounds his portion of the gain; againſt 54, the portion of D, is 9, his portion of the gain; and againſt 42 pounds on the firſt, the portion of E, is 7 pounds, on the ſecond, his portion of the 50 pounds gain, Thus much is each mans ſeveral portion of the 50 pounds gain; all which ſeveral portions of the gain added together, make up the whole gain of 50 pounds.

Thus upon our lines can we work that rule of Arithmetick, called *The Rule of Fellowſhip*; which is, when diverſe men adventure a ſtock of money together, and therewith trade, and either gain or loſe a certain ſum of money, to find each mans portion of the gain or loſſe, anſwerable to his portion of money put into the ſtock.

PROBLEM X.

Of Intereſt and Annuities.

To find the Intereſt of any ſum of money, after any rate by the 100 *propounded.*

WHat is the Intereſt of 65 pounds for a year, after the rate of 8 in the 100?

By

By the rule of Proportion, the queſtion is thus reſolved:

As 100, is to 108; So is 65, to the fourth term.

Set 1 or 100 on the firſt, to 108 on the ſecond, and then againſt 65 on the firſt, is 70, 2 on the ſecond, which is 70 pounds 4 ſhillings; ſo much doth the principal and intereſt ariſe unto in a year, that is to ſay, five pounds and four ſhillings: And without ſtirring the Inſtrument againſt any other ſum of Principal on the firſt, is the Principal and Intereſt thereof on the ſecond. As againſt 40 pounds, is 43 pounds 4 ſhillings; and againſt 80 pounds, is 86 pounds and 8 ſhillings. From whence it appeareth, that 3 pounds 4 ſhillings is the Intereſt of 40 pounds for a year; and 6 pounds 8 ſhillings, the Intereſt of 80 pounds for a year. In like manner, againſt 27 pounds 14 ſhillings Principal, or 27,7 is 29 pounds 18 ſhillings, and a little more.

Or elſe work thus.

Set 1 or 100 back to 8, and then againſt 65 on that firſt, is 5,2 on the ſecond; and againſt 40 pounds on the firſt, is 3, 2 on the ſecond: So the Intereſt of the one is 5 pounds 4 ſhillings, and of the other 3 pounds 4 ſhillings.

If the rate of the Intereſt propoſed be 6 in the 100, then ſet 100 on the firſt, to 106 on the

second; and then against 65 pounds on the first, is 68 pounds 18 shillings on the second, which is the Principall and Interest together of 65 pounds for a year. Or,

Set 100 on the first, to 6 on the second, and then against 65 on the first, is 3,9 on the second this 3,9 is 3 pounds 18 shillings, the Interest alone of 65 pounds for a year, and so of any other.

Of Interest of money continued from year to year.

The increase or Interest of money from year to year for many years, is in continual proportion to the Principal, as 100 is to its Interest; as if 40 pounds were to be continued at Interest for many years, at the rate of 6 in the 100.

Set 100 on the first, to 106 on the second, and then against 40 on the first, is 42,4 on the second, that is 42 pounds 8 shillings, so much is the first years Principal and Interest. And now, if you look 42,4 on the first, you shall have right against it 44,9 and more, that is 44 pounds 18 shillings and more, for the Principal and Interest of two years; and against, 44,9 on the first, is 47.6 and better, on the second, that is 47 pounds 12 shillings 8 pence, the Interest and Principal of 40 pounds in three years. Again, against 47,6 on the first, is 50,45

and

and better, that is 50 pound 9 ſhillings 7 pence; So much is the Principal and Intereſt together of 40 pounds at the end of 4 years, and ſo forth to as many years as is required.

Of Annuities.

When lands are ſold at certain years purchaſe, according to the yearly rent, to find what their value upon the purchaſe will be: Set 1 on the firſt, to the number of years purchaſe on the ſecond; and then againſt their yearly rent on the firſt, is the value of the purchaſe on the ſecond.

Example. Let a houſe and land worth 16 pounds a year, be ſet to ſale at 14 years purchaſe, and demand made, how much money it will ariſe unto at that rate.

Set 1 on the firſt, to 14, the number of years purchaſe on the ſecond; and then againſt 16, the yearly rent on the firſt, is 224 on the ſecond which is 224 pounds: So much mony doth the purchaſe ariſe unto, of 16 pounds a year bought at 14 years purchaſe.

If the price of the lands be given, and that it coſt after 14 years purchaſe, to find what yearly rent it was ſold at. In this caſe, Set 14 on the firſt, to 1 on the ſecond; and then againſt the ſum of money paid 224 pound, is 16, which is 16 pounds: So much is the yearly rent ſought.

A man

A man borrowed 666 pounds 13 shillings and 4 pence for 12 years, and covenanted that he would repay at the 12 years end 1333 pounds 6 shillings and 8 pence. It is desired to know after what rate of Interest by the 100, he paid for his money borrowed.

Set $1333\frac{1}{3}$ on the first, (the sum of money to be paid, to 666^{2} on the second (the summe lent) and then against 12 on the second (the term of years it was lent) is 5,95, which is 5 pounds 19 shillings: So much by the 100 doth he pay for the money lent.

A Sum of money being due at a certain time to come, to find what it is worth in present money, to take in.

There is 402 pounds 2 shillings due at the end of 5 years to come, I would know what it is worth in ready money, abating Interest for the money received in, before due, after the rate of 8 in the 100.

First, set 108 on the first, to 100 on the second, and then against 402, 1 on the first, is 37,1 on the second. Secondly, against 37, 1 on the first, is 34,46 on the second. Thirdly, against 34, 46 on the first, is 31, 95 on the second. Fourthly, against 31,95 on the first, is 29,71 on the second. Fifthly, against 29,71 on the first, is 373 on the second. So much, namely,

namely, 373 pounds may be received in present money for the 402 pounds and 2 shillings due 5 years hence, as being the present worth thereof.

Here take notice, that as the Principal and Interest of money forborn for many years, increaseth in a proportion direct; So in this case, where money is paid many years before due, it decreaseth in the like proportion.

CHAP.

CHAP. III.

The Use of the double Scale of Numbers in Superficial measure, as Board, Glasse, Land, and the like.

PROBLEM. I.

The length and breadth of any square, or long square Superficies being given, to find the Content thereof.

IF the length and breadth be given in inches, Then,

As 1 to the breadth in Inches, So is the length in Inches, To the Content in Inches.

Example. Let a plain Superficies, as a Board or Plank be given to be measured, the breadth is found 30 Inches, and its length 183, and the Content required.

Set 1 on the first, to 30 on the second, and then against 183 on the first, is 5490, the Content sought in Inches.

If the Superficies given, be a piece of land, 30 perches broad, and 183 long, the Content is 5490 perches.

Again, let a piece of Wainscot be 2, 5 foot

in

in breadth, and 15,25 foot in length, the Content will be found 38,12 foot. For,

Set 1 on the first, to 2,5 on the second, and then against 15,25 on the first, is 38,12 foot, the Content sought.

PROBLEM II.

The breadth and length of any Superficies being given in one kind of measure, to find the Content in another kind of measure.

LEt the length and breadth be given in Inches, and the Content required in feet.

The Rule is thus:

As 144 to the breadth in inches, So is the length in inches, To the Content in feet.

Example. Let the breadth be 30 inches, and the length 183 inches, and the Content in feet required.

In this case, because 144 inches make a foot of superficial measure, Set 144 on the first, to 30 the breadth on the second, and then against 183, the length on that first, is 38 foot, and a Fraction of a foot, being a little more than one tenth part of a foot: So many foot are in that Board, or what other platform it be, that is given to be so measured.

If the platform were a piece of land 30 perches broad, and 183 perches long, then the Analogie

Analogie is thus: As 160, (the perches making an acre) to the breadth in perches; So is the length in perches, To the Content in acres.

And therefore in this case of land measure, Set 160 on the first, to 30 the breadth on the second; and then against 183, the length on that first, is 34,31 on the second: So many acres of land are contained in that ground.

If the place, whose Content is to be cast up, be a Triangle, a Trapezia, or of any other form whatsoever, the Analogie in general is this;

As 144, or 160,&c. is to one of the numbers given to be multiplyed together; So is the other of them, to the Content in Feet or Acres,&c.

There is a piece of Wainscot, that is 3,5 foot broad, and 21 foot long: How many yards is in it?

Seeing that in a yard are contained 9 foot; Therefore, Set 9 on the first, to 3,5 on the second; and then against 21 on the first, is 8,16 on the second: So many yards is in that piece.

PRO-

PROBLEM III.

The breadth of a Superficies being given in one kind of measure, and the length in another, to find the Content in the greater measure.

LEt the breadth of a Superficies given be in inches, and the length in feet, and the Content in feet required:

Here the Analogie is:

As 12 to the breadth in inches; So the length in feet, to the Content in feet:

So that if the breadth be 30 inches, and the length 15,25 foot, the Content will be 38,12 foot: For,

Set 12 on the first to 30 on the second; and then against 15,25 on the first, is 38,12 on the second, being the Content sought for: Or else,

Set 12 to 15,25, and then against 30 on that first, is 38,12 on the second.

By this rule also: If the breadth of a plot of land be given in perches, and the length in chains (being measured by a chain of 4 perches long) the Content in Acres is readily had.

Example. Let a piece of land be in breadth 30 perches, and in length 15,25 chains, measured by a chain of 4 perches in length.

In this case the Analogie is thus:

As 4 is to the breadth in poles, So is the length

length in chains to the Content in Acres. Therefore, set 4 to 30, and then against 15,25 on that first side whereon the 4 is, you shall have 11,4 on the second side: So much is the Content in Acres of that piece of land.

Again, let a piece of land be 36 poles broad, and the length 23 chains and an half; to find the Content.

Set 4 on the first, to 36 on the second, and then against 23,5 on that first, is 21,1 and better on the second: the Content fought.

PROBLEM. IV.

The length and breadth of a Superficies being given in feet, to find the Content in yards.

TAke this for a general Rule: As 9 is to the breadth in feet; So is the length in feet, To the Content in yards.

Example. Let the breadth of a pane of Wainscot be 4 foot, and the length 12 foot, and the Content in yards be sought for.

Here is no more to be done, but to set 9 on the first, to 4 on the second; and then against 12 on the first, is 5,35 on the second: The Content in yards of that pane, which is almost 5 yards, a quarter and an half, or rather 5 yards and one third part of a yard.

PRO-

PROBLEM. V.

The breadth of any Superficies being given in inches or feet, to find how much in length will make a ſuperficial foot.

The Rule is thus.

AS the breadth in inches, to 144; So is 1 to the length in inches, to make a foot.

Example. Let the breadth given be 30 inches, and the length to make a foot at that breadth be required.

Set 30 on the firſt, to 144 on the ſecond, and then againſt 1 on the firſt, is 4,8 on the ſecond: So much in length makes a foot at 30 inches broad.

But if the breadth be given in feet; Then,

As the breadth in feet is to 1, So is 1 to the length to make a foot: Therefore,

Set 2,5 on the firſt, to 1 on the ſecond, and then againſt 1 on the firſt ſide, is 4 on the ſecond, which 4 ſignifieth four tenth parts of a foot: So much in length makes a foot at that breadth.

PROBLEM VI.

The length and breadth of a plot of land being given in chains, to finde the Content in Acres.

HAving a chain of 4 perches long, divided into 100 links, that is, 25 in the perch; meaſure the length and breadth of the land to be meaſured in chains and links: And then caſt up the Content into Acres thus:

As 10 to the breadth in chains;
So is the length in chains, to the Content in Acres.

Example, Let the breadth given be 7 chains 50 links, and the length 45 chains, 75 links, and the content in Acres ſought:

Set 10 on the firſt, to 7,5 on the ſecond, and then againſt 45,75 on the firſt, is 34,31 on the ſecond, which is the Content in Acres of that plot of land. Or,

Had the breadth been 15 chains, 25 links, and the breadth 22 chains, 50 links; then ſet 10 or 1 on the firſt, to 15,5 on the ſecond, and then againſt 22,50 on the firſt, is 34, 31 on the ſecond, the Content in Acres ſought for: which Fraction 31 above the 34 Acres, contains 1 rood 10 perches. So that the Content is 34 Acres, 1 rood and 10 pole.

If the plot of land be of a Triangle form, or any

any other figure whatſoever, the Analogie is this:

As 10 is to one of the two numbers of chains, that are to be multiplyed together: So is the other of them, to the Content in Acres.

As if the half perpendicular of a Triangle be 3,75 chains, and the Baſe 45,75, the Content will be found to be 17,15 Acres.

For ſet 10 on the firſt, to 3,75 on the ſecond, and then againſt 45,75 on that firſt, is 17,15, the content.

Or elſe, having the whole Baſe, and whole perpendicular, ſay thus: As 20 to the whole perpendicular 7,50; So is the whole Baſe 45,75; To 17,15 the content in Acres, as before: For,

Set 20 on the firſt, to 7,50 on the ſecond, and then againſt 45,75 on the firſt, is 17,15 on the ſecond.

Or if the Baſe of a Triangle be 36,83 chains and the perpendicular 17,59 chains, the content will be found by either way of working, to be 32,39, which is 32 acres, 1 rood 22 perches.

PROBLEM. VII.

The Content of a piece of land being measured by one kind of perch, to find the Content thereof, after another kind of perch.

THese kind of proportions are wrought by the Rule of Three reverse, after a duplicated proportion; and the Analogie is thus:

As the length of the second pearch,
is to the length of the first perch:
So the content in acres given,
to a fourth number: and so is that fourth number to a fifth number, which is the content sought.

Suppose a piece of land measured by the 16½ foot-pole, do contain 34, 3 acres, and it be demanded; How much it would contain, if it were measured by an 18 foot-pole:

Note that I call the 16½ foot-perch, the first perch, because by it the land was measured; and the 18 foot-perch I call the second perch, because according to it the content is sought for. Wherefore,

Set the second perch 18 on the first, to 16,5 on the second, (the perch first used) and then against 34,3, the content in acres given, on the first, is 31, 45 on the second; and then against that 31,45 on that first, is 28,8 on the second:

So

So much is the content in acres by the 18 foot pole, which was demanded.

In like manner, were the content given 5 acres, 2 roods, 20 pole, or 5,62: Set 18 on the first, to 16,5 on the second, and then against 5,62 on the first, is 5,15 on the second. And lastly, against that 5,15 on that first, is neer about 4,7 on the second: So much is the content of that close by the 18 foot pole.

PROBLEM. VIII.

The one side of any piece of land being given, to find how much in breadth the other way will make an Acre of land.

LEt the side of a close be 20 pole, and it be required; How much in breadth will make on acre of land at that length.

Set the breadth given, 20 on the first, to 160 on the second; and then against 1 or 10 on that first, is 8 on the second. So much in breadth makes an acre at 20 pole long.

Or if the side measured be 25, then set 25 to 160, and against 1 on that first, is 6,4 on the second, the breadth sought for. And if the length be 32 pole, the breadth to make an acre will be 5 pole.

PROBLEM. IX.

A plot of land being laid down, and cast up by any Scale, to find how much it will contain by any other Scale, either greater or lesser.

SUppose a plot of land being laid down, and cast up by a Scale of 10, in the inch, does contain 28, 5 acres; and it is required to know how many acres it will contain, should it be cast up by a Scale of 12 in the inch.

Here because 12, the Scale to be used, is lesser than 10, the Scale formerly used: And so by consequence, the content of the given plot by the Scale of 12, will be more acres than it is by the Scale of 10 in the inch.

Therefore,

Set the Scale used 10 on the first, to the Scale to be used 12 on the second, and then against the content known 28, 5 on the first, is 34, 2 acres, or neer thereabouts on the second: So much is the content by the Scale of 12 in the inch.

But if the plot had been laid down, and cast up by a Scale of 12, and the content required by a Scale of 10 in the inch, which is the greater Scale, and therefore the content is the lesser. Then,

Set 12 on the first, to 10 on the second, which

which done, right against the content in acres by the Scale of 12 on the first, is the content by the Scale of 10 on the second: As if the content by the Scale of 12 be 34,2 acres, then the content by the Scale of 10, will be found to be 28,5 acres neer. For,

Set 12 on the first, to 10 on the second, and then against 34,2 on the first, is 28,5 on the second.

PROBLEM. X.

The Diameter of a circle being given, to find the Circumference.

The Analogie stands thus:

AS 1 is to the Diameter; So is 3, 142 to the Circumference. Or,

As 7 to 22; So is the Diameter to the Circumference. If the Diameter be 15 inches, what is the Circumference? Set 1 on the first, to 15 on the second, and then right against 3, 142 on the first, is 47,13 on the second: So much is the Circumference of that circle. Or,

Set 7 on the first, to 22 on the second, and then against 15 on the first, is 47,13 on the second, as before.

PROBLEM. XI.

The Circumference of a circle being given, to find the Diameter.

AS 22 is to 7, So is the Circumference to the Diameter. Or,

As 3,142 to 1, So is the Circumference to the Diameter. So if the Circumference be 47, 13, what is the Diameter?

Set 22 on the first, to 7 on the second, and then against 47,13 on the first, is 15 on the second: So much is the Diameter of that circle. Or,

Set 3,142 to 1, and then against 47,13 is 15, as before.

PROBLEM. XII.

The Diameter of a circle being given, to find the side of a Square equal to it.

THe Diameter of a circle is 15 inches, what is the side of the square equal to it in Content?

Set 1 on the first, to 15 on the second, and then right against this number 8862 on the first, is 13,29 on the second: So much is the side of a square, that is equal in Content to that circle.

PRO-

PROBLEM. XIII.

The Circumference of a circle being given, to find the side of a square, equal in Content to that circle.

LEt the Circumference of a circle be 47,13, and the side of a square equal to it be required.

Set 1 on the first, to 47,13 on the second, and then alwayes against this number 2821 on the first, is 13,29 on the second: So many inches is the side of a square, that is equall in Content to the circle given.

PROBLEM. XIV.

The Diameter of a circle being given, to find the side of a square, that may be inscribed within it.

LEt the Diameter of a circle be 15 inches, and it be required, what the side of that square will be, that may justly be inscribed within it?

Set 1 on the first, to that 15 on the second, & then against this number 7071 on the first, is neer about 10,6 on the second: Therefore 10,6 inches, is the side of a square that may be inscribed within a circle of 15 inches Diameter.

Or thus it may be found:

Double the ſquare of the Semidiameter, the Root ſquare of that Product is the ſide of the ſquare inſcribed; but this is by the By.

PROBLEM. XV.

The Circumference of a circle being given, to find the ſide of a ſquare that may be inſcribed within it.

LEt the Circumference given be 47,13, and the ſide of a ſquare that may be inſcribed within it, be required.

Set 1 on the firſt, to the Circumference 47,13 on the ſecond; and then againſt this general number 2251 on the firſt, is neer about 10,6 on the ſecond: So many inches is the ſide of that ſquare, that can be inſcribed within the circle given.

PROBLEM XVI.

The Diameter or Circumference of a circle, either of them being given, to find the ſide of an Equilater triangle, to be inſcribed within that circle.

FIrſt, having the Diameter given, which ſuppoſe 14 inches, and it be required, to find the ſide of the Equilater Triangle that may be inſcribed in that circle.

Set

Set 1 on the first, to 14 on the second, (that is, to the Diameter given) and then against this general number 8,65 on the first, is 12,1 on the second: Therefore conclude, that 12 inches and one tenth part of an inch, is the length of the side of that Equilater Triangle, which may be inscribed within a circle of 14 Inches Diameter.

Or you may set 1 to the general number 865, and then against 14 is 12,1, as before.

Having the Circumference given, which let it be supposed to be 44, then to find the side of that Equilater Triangle, the work is thus.

Set 1 on the first, to the Circumference given 44 on the second, and then against this general number 272,6 on the first, is 12,1 on the second, the side of the Equilater Triangle sought for.

Or, Set 1 to that general number 272,6, and then against 44, is 12,1, and so of any other.

PROBLEM. XVII.

The Diameter or Circumference of any circle being given, to find the superficial Content.

LEt the Diameter of a circle proposed be 15 Inches, and the superficial Content of it demanded.

Set 1 on the first, to 15 on the second, & then against

then againſt this general number 7854 on the firſt, is 11,83 on the ſecond; and then again, againſt that 11,83 on the firſt, is 176,74 on the ſecond: This 176,74 is the Content of that circle propoſed.

But if the Circumference of any circle only be given, as if it were given 47,13, and the Content required. Then,

Set 1 on the firſt, to the Circumference given, 47,13 on the ſecond; and then againſt this general number 7958 on the firſt, is neer 37,8 on the ſecond: And laſtly, againſt this 37,8 on the firſt, is 176,74 on the ſecond, the Content required.

PROBLEM. XVIII.

The Diameter, with the ſuperficial Content of any circle given, to find the Content of any other circle that is twice the Diameter of the firſt.

LEt the Diameter of a circle given be 7 inches, and the Content 38,5 inches, and the demand be, to know what another circle is, that is double in Diameter to the former.

Set 7 on the firſt, to 14 on the ſecond, and then againſt the known Content 38,5 on the firſt, is 77 on the ſecond; and then again, againſt that 77 found on the firſt, is 154 on the ſecond: So much is the Content of that other

circl.

circle, whoſe Diameter is double to the Diameter of the circle given, that is to ſay, of 14 inches Diameter.

PROBLEM. XIX.

The Content of a circle being known, to find the Diameter and Circumference.

LEt the Content of a circle be known to be 176,74 inches, and it be required to know what the Diameter of that circle is, as alſo what the Circumference is.

For the Diameter, Set 1 on the firſt, to 1,273 on the ſecond, and then againſt the Content known, 176,74 on the firſt, is 225 on the ſecond; the ſquare root of this 225 is 15: So many inches is the Diameter of that circle.

For the Circumference, Set 1 on the firſt, to this general number 12,57, and then againſt 176,74 on the firſt, is neer 2221, whereof the ſquare root is 47,13: So many inches is the Circumference of that circle.

The Root ſquare of the Content of any circle, is the ſide of a ſquare equal to it.

CHAP.

CHAP. IV.

The Use of the double Scales in solid measure, such as Timber, Stone, &c.

PROBLEM. I.

The side of a square solid being given in inches, or feet, to find how much in length will make a foot solid in inches or feet.

SUppose the side of a square log be 25,45 inches, and demand is made, How many in length will make a foot.

Set the breadth given, 25,45 on the first, to this general number 41,57 on the second; and then against 1 on the first, is 1,63 on the second, and against this 1,63 found on the first, is 2,67 on the second: So much in length makes a foot of Timber, *viz.* 2 inches, and 67 parts of 100.

If the breadth be given in parts of a foot (the foot being divided into 100 or 1000 equall parts) to find what parts of a foot in length will make a foot of Timber. As if the breadth of a piece of Timber be 2 foot and 120 parts of 1000 of a foot; then to find how much in length will make a foot solid.

Set

Set 2,120 on the first, to 1 on the second, and then against 1 on the first, is 471 on the second; and lastly, against that 471 on the first, is 222: So many parts of a foot (it being divided into 1000) do make a foot of Timber at that breadth.

PROBLEM. II.

The breadth and depth of an unequal square solid being given in parts of a foot, or in inches, to find how much in length will make a foot.

LEt the breadth of a piece of Timber be 2,5 foot, and the depth 1,8 foot. Here first, by Multiplication find out the Content of the Base or end, which you shall find to be 4,5, which being had, get the length of a foot solid thus:

Set the Content of the head found, 4,5 on the first, to 1 on the second; and then against 1 on the first, is 222 on the second: So many parts of a foot divided into 1000, do make a foot of Timber.

But if the breadth be given 30 inches, and the depth 21,6, then the Content of the Base will be 648, and the work thus wrought.

Set 648 on the first, to 1728 on the second; and then against 1 on the first, is 11,27 on the second; and lastly, look this 11,27 on the first,

first, and right against it on the second, is 2,67 inches, the length of a foot of Timber in that log, whose breadth is 30 inches, & depth 21,6.

Or you may work thus:

Set 12 on the first, to 21,6 on the second, and then against 30 on the first, is 54 on the second; This done, set the new found number 54 on the first, to 144 on the second; and then against 1 on the first, is 2,67 on the second, the length to make a foot, as before.

Such an unequal squared piece of timber, as is here mentioned, may be reduced into a perfect square, and wrought as in the first Problem. And so the perfect square of this unequal squared log, whose breadth is 30 inches, and depth 21,6, will be found to be 2, 120 foot. Or 25,40 inches, and now you may proceed herewith, as in the first Problem you do with square Timber.

PROBLEM. III.

The breadth of a square solid, or the side of a square equal to the Base of any unequal square solid, and the length of the same solid being given in inches or feet, to find the Content in feet.

First, suppose the breadth and length be given in inches, as let the breadth be 25 inches,

ches, and 45 parts of an inch, and the length 183 inches, and the Content demanded.

Set this general number 41,57 on the first, to the side of the square given 25, 45 on the second, and then against the length in inches 183 on the first, is 112 on the second: And again, against that 112 on the first, is 68,62 on the second: Therefore the Content of the piece of Timber proposed is 68 foot, and 62 parts of a foot into 100 divided.

But if the breadth be given in feet, and parts of a foot; As let the breadth of the solid be 2 foot, and 12 parts of a foot, such as the whole foot is divided into 100, and the length 15 foot and 25 parts. Then,

Set 1 on the first, to 2,12 on the second, that is to the breadth given; and then against 15,25 on the first, is 32,35 on the second: And lastly, against that 32,35 on the first, is 68,62 on the second: So much is the Content in feet of that solid.

If an unequal squared solid be to be measured, it is as good a way as any, to reduce it to a perfect square, and then compute the Content as here before, and this reduction is easily made for multiply the breadth by the thickness, and the Product is the Content of the Base, whereof the square root is the side of a perfect equal square, to that unequal square given.

PROBLEM. IV.

The ſide of a ſquared ſolid given in inches, and the length in feet, to finde the Content in feet.

LEt the ſide of a perfect ſquare ſolid be 25 inches, and 45 parts of an inch, ſuch as the whole inch is divided into 100; and the length 15 foot, and 25 parts of a foot, Such as the whole foot is divided into 100, and the Content in feet required.

Set alwayes 12 on the firſt, to the breadth in inches 25, 45 on the ſecond; and then againſt 15, 25 the length in feet, is 32, 35 on the ſecond: This 32, 35 found on the firſt, and right againſt it on the ſecond is 68, 62: So many foot of Timber, and parts of a foot, are in that log.

If an enequal ſquare ſolid be to be meaſured, reduce the Baſe of that unequal ſquare ſolid into a perfect ſquare, and then find the Content as here is taught.

PROBLEM. V.

The length, breadth and depth of a ſquare ſolid being given in inches, to find the Content in feet.

BY the breadth and depth, get the Content of the Baſe; as let the length of a piece of Timber

Timber be 183 inches, the breadth 20 inches, and the depth 13 inches, and the Content in feet desired: Here 20 and 13 multiplied together, make 260 for the Content of the Base.

Now, Set 1728 on the first, to 260, the Content of the Base on the second; and then against 138, the length on the first, is 27, 5 neer on the second: Wherefore you may conclude, that in the piece of Timber proposed is contained 27 foot and an half, with a little more, which is inconsiderable,

Or else you may work it thus:

Set 12 on the first, to 13 the depth on the second, and then against 20 the breadth on the first, is a fourth number, *viz.* 21,70 on the second. This done, Set 144 on the first, to this fourth number new found 21, 70 on the second; and then against 183, the length of the piece on the first, is 27, 5 on the second: So that the Content of that piece of Timber, is 27 foot and an half, as before.

Or you might have set 12 on the first, to 20 on the second, and then against 13 on the first, you should have had 21,70 on the second, for the fourth number, as afore; to which set 144 on the first, and then against 183, is 27 foot and an half.

PROBLEM. VI.

The Base of any square solid being given in inches, and the length in feet, to find the Content in feet.

LEt the Base of a piece of Timber contain 260 inches, and the length 15 foot and a quarter, and the content thereof in feet desired.

Set 144 on the first, to the Content of the Base 260 on the second; and then against 15,25 on the first, is 27,5 on the second. So then 27 foot and an half is the Content desired.

If both the length and content of the Base be given in feet; then Set 1 on the first, to the Content of the Base in feet on the second, and then against the length in feet on the first, is the Content in feet on the second: As if the length of a piece of Timber be 15 foot and a quarter, and the Content of the Base 4 foot and an half.

Set 1 on the first, to 4 and an half on the second, and then against 15 and a quarter on the first, is 62,68 on the second; that is 68 foot and an half, and almost half a quarter: So much is the Content of that piece.

PRO-

PROBLEM. VII.

The Diameter of a Cylender given in inches or feet, to find the length of a foot, according to that Diameter.

LEt the Diameter of a Cylender, or round piece of Timber or Stone be 15 inches, and it be demanded, How much in length makes a foot solid?

Set the Diameter 15 on the first, to this general number 46,90 on the second, and then against 1 on the first, is 3,13 on the second; and then against that 3,13 found on the first, is 9,78 on the second: So much in length makes a foot of Timber, that is 9 inches, and 78 parts of 100, of an inch.

But if the Diameter be taken in feet, and parts of feet, then set the Diameter 1,25 on the first, to this general number 1128 on the second, and then against 1 on the first, is 9027 on the second, and against this 9027 found on the first, you have 8,15 on the second, that is 8 parts of a foot, such as the whole foot is divided into 10 parts, and 15 parts of 100 of one tenth over: So much in length makes a foot.

PROBLEM. VIII.

The Circumference of a Cylinder given in inches or tenth parts of feet, to find the length to make a solid foot.

LEt the circumference of a round log be 47 inches, and 13 hundred parts of an inch, and the length to make a foot, desired.

Set the circumference 47,13 on the first, to 147,36 on the second, and then against 1 on the first, is 31,2 on the second; and against that 31,2 on the first, is 9,78 on the second: So many inches and parts in length make a foot solid.

But if the circumference be given in feet and parts of feet, as let the fore-mentioned Cylinder be measured by feet, and parts of feet, and be found to contain 3 foot and 93 parts of a foot. Then,

Set the circumference 3,93 on the first, to this number 3545 on the second, and then against 1 on the first, is 903 on the second; and then against 903 found on the first, is neer 8,15 on the second: So much is the length in foot measure to make a foot

PRO-

PROBLEM. IX.

The Diameter and length of a Cylinder given in inches or feet, to find the Content in inches, or tenth parts of feet.

LEt the Diameter of a Cylinder be 15 inches, and the length 105 inches, and the Content in inches sought for.

Set this number 1128 on the first, to 15 on the second, the Diameter known; and then against the length 105 on the first, is 1396 on the second; and again, against this 1396 on the first, is 18553,5 on the second: The whole Content in inches, which divided by 1728, giveth 10 foot, and almost three quarters.

But if the Diameter and length be taken by foot-measure, as let the Diameter be 1,25 foot and the length 8,75 foot. Then,

Set the number 1128 on the first, to 1, 25 (the Diameter in foot measure) on the second; and then against 8,75, the length on the first, is 9,69 on the second. And lastly, against 9, 69 on the first, is 10, 737 foot, or 10 foot, and almost three quarters: the Content sought for, as before.

PROBLEM. X.

The Diameter and length of a Cylinder given in inches, to find the Content in feet.

LEt the Diameter of a circle be 15 inches, and the length 105 inches, and the Content in feet desired.

Set this number 4690 on the first, to 15 the Diameter on the second, and then against 105, the length on the first, is 33,58 on the second; and again, against this 33,58 on the first, is 10,737 on the second: So then 10 foot, and almost three quarters, is contained in that Cylender.

PROBLEM. XI.

The Diameter of a Cylinder given inches, and the length in feet, to find the content in feet.

LEt a Cylinder be given to be measured, whose Diameter is 15 inches, and the length 8 foot, and 75 parts of 100 of a foot, and let it be required by these measures only to give the Content in feet.

Set this general number 1354 on the first, to 15 the Diameter on the second; and then against 8,75 the length in feet on the first, is 969 on the second: And lastly, against this 969 on the

the first, is 10,74 on the second: So much doth that Cylinder contain *viz.* 10 foot and almost three quarters.

PROBLEM. XII.

The circumference and length of a Cylinder given in inches, to find the Content in inches.

LEt a Cylinder be given to be measured, whose length is 105 inches, & its circumference 47,13 inches, & let it be required only by these measures, to give the Content in inches, which to do:

Set this general number 3545 on the first, to 47,13 on the second (that is the circumference) and then against 105, the length on the first, is 1396 on the second. Now again, against this 1396 on the first, is 18555: So many inches are contained in that Cylinder.

PROBLEM. XIII.

The Circumference and length of a Cylinder given in inches, to find the content in feet.

LEt the fore-mentioned Cylinder be proposed, whose length is 105 inches, and the circumference 47,13 inches, and the content in feet required by this measure only. In this case,

Set

Set this general number 14736 on the first, to 47,13 on the second, and then against 105, the length in inches, is 35,58 on the second, and against this 3358 on the first, is 10,71 on the second, which is 10 feet and 74 parts of 100 of a foot.

But if the circumference and length be given in foot measure, as if the circumference be 3,927 foot, and the length 8,75 foot, and the Content in feet required. Then,

Set this general number 3545 on the first, to 3,927 the circumference on the second, and then against 8,75 the length on the first, is 969 on the second; and again, against that 969 on the first, is 10,74 on the second: So much is the Content in feet required.

PROBLEM. XIV.

The Circumference of a Cylinder taken in inches, and the length in feet, to find the Content in feet.

IN the Cylinder afore proposed, having the circumference in inches 47,13, and the length in feet 8,75. I thereby to find the content in feet, do work thus:

Set this general number 4254 on the first, to the circumference in inches 47,13 on the second, and then against 8,75 the length in feet on

on the first, is 969 on the second; and lastly, against this 969 on the first, is 10,74 on the second: So much is the content in feet.

PROBLEM. XV.

The Diameters of any vessel at the head, and at the bung, with the length in inches had, to find the content thereof, first in inches, and then in gallons, either of Wine or Beer,

LEt the length of a vessel be 40 inches, the Diameter at the head 18 inches, and the Diameter at the bung 32 inches, and the content of the vessel in inches and gallons is sought for. Which to find,

You must first get two third parts of the Content of a circle answerable to the Diameter at the bung; and one third part of the Content of a circle answerable to the Diameter at the head, and add them two numbers together, and their total multiply by the length of the vessel, and the Product is the Content in inches.

Now to get the two third parts of the circle at the bung; Set 1 on the first, to this general number 5236 on the second, and then against 10 24, the square of 32, the Diameter at the bung is 536, 166, which is two third parts of the content of that circle at the bung,

For the one third part of the circle at the

head

head; Set 1 on the first, to this general number 2618 on the second, and then against 324, the square of 18 the diameter at the head on the first, is 84,823 on the second, which is one third part of the content of the circle at the head.

These two numbers 536, 166 and 84, 823 added together, make 602,989. This 620,989 multiply by 30, and it giveth 24839, 56: So many inches are contained in it.

And now to know how many Wine-gallons are in this vessel, divide the content in inches 24839,56 by 231, which is the number of inches contained in a Wine-gallon, and the quotient is 107,53: So many Wine-gallons are in that vessel.

To know how many Ale or Beer-gallons are in it, divide 24839,56 the content in inches, by 272,25, which is the number of inches in a Beer-gallon, the quotient is the content of the vessel in Beer-gallons. How to multiply and divide is shewed before, and therefore I need not shew it here again.

CHAP.

CHAP. V.

The Use of the double scales of Numbers in Spherical Bodies, such as Globes, Bullets, &c.

PROBLEM. I.

The Diameter of any Spherical Body being known, to find the circumference.

LEt the Diameter of a Bullet be 9 inches, and the circumference sought for.

Set 7 on the first, to 22 on the second, and then against 9 on the first, is 28, 28 on the second: So many inches is the circumference of a bullet of 9 inches diameter.

PROBLEM. II.

The circumference of any Spherical Body being known, to find the Diameter.

LEt the circumference of a Bullet be 28, 28 inches, and the diameter sought for.

Set 22 on the first, to 7 on the second, and then against 28, 28 on the first, is 9 on the second

cond, that is, 9 inches in the diameter of that Bullet, whose circumference is 28 inches, and 28 hundred parts of an inch.

PROBLEM. III.

The Diameter and circumference of any Spherical Body being known, to find the Superficial Content.

LEt the diameter of a Globe be 9 inches, and the circumference 28,28 inches, and it is demanded, How many square inches, the Superficies of that Globe doth contain? Then,

Set 1 on the first, to 9 the diameter on the second, and then against 28,28 on the first, is very near 254,5 on the second: So then 254,5 inches and an half, are contained in the Superficies of that Globe.

Or else by knowing onely the diameter, work thus; Set 1 on the first, to this number 3,1416 on the second; and then against 81, the square of the diameter on the first, is 254,5 on the second, as before; here you see are two wayes of working, and both agreeing: So that one proveth the other.

PRO-

PROBLEM. IV.

The Axis or Diameter of a Globe being known, to find the ſolid Content.

IF the diameter of a Globe be 9 inches, what is the ſolid content in ſquare cubick inches?

For reſolving this and the like queſtions, the Rule is this; As the diameter is to the Cube of it ſelf, ſo is 11 to the ſolid Content, The Cube of 9 the Diameter known is 729, which Cube, if you know it not, is thus found.

Set 1 on the firſt, to 9 on the ſecond, and then againſt 9 on the firſt, is 81 the ſquare of 9, on the ſecond: and laſtly, againſt this 81 on the firſt, is 729 on the ſecond, which is the Cube of 9, the Cube being had.

Set 9 on the firſt, to 729 on the ſecond, and then againſt 11 on the firſt, is 891 on the ſecond: Therefore 891 cubick inches are contained in the ſolid body of that Globe. Or,

Set 1 on the firſt, to 9 on the ſecond, and then againſt 11 on the firſt is 99 on the ſecond, and next againſt this 99 on the firſt, is 891 on the ſecond, as before.

If the Diameter be 21 inches, then ſet 21 on the firſt, to 9261, its Cube on the ſecond; and then againſt 11 on the firſt, is 4851 on the ſecond:

second: So many cubick inches are in a Globe of 11 inches diameter. Or,

Set 1 to 21, and then against 11 is 235, and against that 235 is 4851, as before.

PROBLEM. V.

The diameter of a Bullet be given, with the weight; to find the weight of another Bullet of the same metal, but of another Diameter, either greater or lesser.

LEt there be propounded an Iron Bullet of 6 inches diameter, weighing 30 pound, and let the question be put, What another Bullet of the same metall will weigh, that is of 7 inches diameter.

Set 6 on the first, to 7 on the second, and then against 30, the weight on the first, is 35 on the second; Secondly, against 35 on the first, is 40,8 on the second; Thirdly, against 40, 8 on the first, is 47,7 on the second: So then the conclusion is, that 47 pounds, and 7 tenth parts of a pound, is the weight of that other Bullet of 7 inches diameter which was sought for.

If a Bullet of 6 inches diameter, weigh 32 pounds, what will a Bullet of the same metal weigh, that is of 3 inches diameter?

Set 6 on the first, to 3 on the second, and then

then againſt 32, the weight on the firſt, is 16 on the ſecond; Secondly, againſt 16 on the firſt, is 8 on the ſecond; and laſtly, againſt 8 on the firſt, is 4 on the ſecond: So then 4 pounds is the weight of that Bullet of 3 inches diameter.

PROBLEM. VI.

Having the ſide of a cubick body of Silver with the worth thereof, to find the worth of another cubick body of ſilver, whoſe ſide is greater or leſſer than that of the body given.

IF a Cube body of ſilver being 4 inches ſquare be worth 12 pounds, What will another Cube body of the ſame metal be worth that is 5 inches ſquare?

Set 4 (the ſide of the body whoſe worth is known) on the firſt, to 5 (the ſide of that body whoſe worth is ſought) on the ſecond; and then againſt 12, the worth known on the firſt, is 15 on the ſecond; next againſt 15 on the firſt, is 18,57 on the ſecond; and thirdly, againſt 18,57 on the firſt, is 23,4 on the ſecond, which is 23 pounds and four tenths of a pound, that is 8 ſhillings: So then the worth of that cubick body of ſilver of 5 inches ſquare is 23 pounds and 8 ſhillings.

PROBLEM. VII.

Having the weight of a Bullet of one kind of metal, to find the weight of a Bullet of another kind of metal, being equal in magnitude.

BEfore I proceed to reſolve this Problem, I will ſhew the proportions between ſome ſeveral metals uſed for this purpoſe, as of Braſs, Iron, Lead and Stone; according to the beſt approved Authors, as followeth.

The proportion between Lead and Iron is as 2 to 3, So that the Leaden Bullet of 3 pounds weight, is equal in diameter with an Iron Bullet of 2 pounds weight.

The proportion between Iron and Stone is as 3 to 8 : Therefore a Stone of 3 pounds weight is equal in bigneſſe to a piece of Iron of 8 pounds weight, and a Stone body of 30 pounds weight, is equal in magnitude to an Iron body of 80 pounds weight, of the ſame form.

The proportion between Lead and Stone is as 4 to 1: So that a Bullet of Lead of 4 pounds weight, and a Stone Bullet of one pound weight, are equal in diameter; and a Leaden Bullet of 40 pounds weight, and a Stone Bullet of 10 pounds weight, are equal in diameter or magnitude.

The

The proportion between Iron and Braſſe, is as 16 to 18; and the proportion between Lead and Braſſe, is as 24 to 19.

Remember that ſome Stone is heavier than other, and ſo likewiſe of metals, the finer they are, the heavier they be, being of the ſame magnitude: but we ſpeak of the ordinary ſort in uſe. And now for reſolving the Problem.

Having the weight of a Bullet of Lead, to find the weight of a Bullet of Marble of the ſame bigneſſe.

If a Bullet of Lead weigh 106 pounds, what will a Bullet of Marble weigh?

By the former Rule it is found, that a Bullet of Lead to the like Bullet of Marble, beareth ſuch proportion as 4 doth to 1. Therefore,

Set 4 on the firſt, to 1 on the ſecond, and then againſt 106 on the firſt, is 26, 5 on the ſecond: So much is the weight of a Stone Bullet, that is equal in bigneſſe to that Leaden one of 106 pounds weight.

On the contrary, having the weight of a Stone Bullet, to find the weight of a Leaden Bullet, of the ſame magnitude.

Set 1 on the firſt, to 4 on the ſecond, and then againſt 26, 5, the weight of the Stone Bullet on the firſt, is 106 on the ſecond, the weight of the Iron Bullet.

There is a Bullet of Iron weigheth 72

pounds, What will a Bullet of Lead weigh that is equal to it in bigneſſe?

Set 2 on the firſt, to 3 on the ſecond, and then againſt 72, the weight known on the firſt, is 108, the weight ſought for on the ſecond.

But if the weight of the Leaden Bullet be given 108, then to get the weight of the Iron Bullet, Set 3 on the firſt, to 2 on the ſecond, and then againſt 108 on the firſt, is 27 on the ſecond: So much is the weight of the Iron Bullet. What is ſaid of a Bullet, is to be underſtood alſo of all round bodies.

CHAP.

CHAP. VI.

The Uſe of the double Scales in the Meaſuration of Concave Cylinders, ſuch as great Ordnance.

PROBLEM. I.

The Diameter and weight of any one Cylinder, or Piece of great Ordnance being known, to find the weight of any other Piece of the ſame metal and ſhape, either greater or leſſer, its Diameter being onely known.

IF a Braſſe Saker, whoſe Diameter is 11,5 inches, do weigh 1900 pounds, what will another Piece weigh, whoſe Diameter is 8,75 inches? For anſwer:

Set 11,5 on the firſt, to 8,75 on the ſecond, and then againſt 1900 on the firſt, is 1440 on the ſecond; Secondly, againſt that 1440 on the firſt, is 1100 on the ſecond; Thirdly, againſt the 1100 on the firſt, is 837 on the ſecond: So much is the weight of that other Piece of Ordnance of 8,75 inches Diameter, it being of the ſame metal and ſhape as the other.

If a Piece of Ordnance of 4 inches Diameter weigh 1600 pounds, What will another Piece weigh that is 6 inches Diameter, being of the same metal and shape?

Set 4 on the first, to 6 on the second, and then against 1600, the weight known, is 2400 on the second; Next against 2400 on the first, is 3600 on the second; And lastly, against 3600 on the first, is 5400 on the second. The weight sought for of that other Piece of 6 inches Diameter.

PROBLEM. II.

Having the Diameter and weight of any Piece of great Ordnance, of one; to find, the weight of another Piece of Ordnance of another metal, that retaineth the same shape.

A Piece of Ordnance being of another sort of metal, there will be required a double work to find out its weight; As let there be a Brasse Piece of Ordnance given, of 11,5 inches Diameter, weighing 1900 pounds; and let the question be, to find the weight of an Iron Piece of Ordnance of the same shape, is 8,75 inches Diameter.

In this and the like cases, you must in the first place, by the former Problem, find the weight of that Piece of 8,75 inches Diameter, as

as if it were a Braſſe Piece, and having found that the weight of it, had it been Braſſe, would have been 837 pounds: You muſt next ſeek the proportional numbers of the two metals, which by the ſeventh Problem of the laſt Chapter, you found was 16 and 18: Such is the proportion between Braſſe and Iron, Braſſe being the heavier metal, Therefore,

Set 18 on the firſt, to 16 on the ſecond, and then againſt 837 on the firſt, (the weight the Piece would have been of, had it been Braſſe) is 744 on the ſecond, the weight of that Piece it being Iron.

PROBLEM. III.

To find the ſuperficial Content of the concave Superficies of any Piece of ordnance, and alſo the ſolid Content of the Concavity thereof.

SUppoſe the Circumference of the Concavity be 12 inches, and the length of it 12 foot, or 144 inches, & the queſtion put, What is the ſuperficial Content of the concave Face, and what the ſolid Content of the concave Bore. For the concave Superficies.

Set 1 on the firſt, to 22, the Circumference of the Concavity on the ſecond, and then againſt 144, the length in inches on the firſt, is 3168 on the ſecond: So many ſquare inches

are in the Superficies of the concave face of the same Piece, which in feet makes 12.

For the solid Content.

First get the Semidiameter, which in this example is 3,5 inches; and also the Semicircumference, which here is 11: These being had,

Set 1 on the first, to 3,5 the Semidiameter on the second, and then against 11, the Semicircumference on the first, is 38,5 on the second: So many square inches are contained in the Base or Plaine of the Concavity of the mouth. This Base had:

Set 1 on the first, to 38,5 the Content of the Base on the second; and then against 144; the length in inches, is 5544 on the second: So many cubick inches are in the solid Content of the Concavity of that Cylinder, which is 3 foot and 360 patts of 1728 of a foot.

PROBLEM. IV.

To know how much of every kind of metal is contained in any Brasse Piece of Ordnance.

IT is said to be an usual thing with Gun-founders, that for every 100 pounds of Copper, to put in 10 pounds of Latten, & 8 pounds of pure Tin. Now supposing this mixture to be true, let it be demanded, How much of every sort of these metals is in a Gun of 5600 pounds weight?

For

For anſwer to this and the like queſtions; Firſt, joyn all the ſeveral mixtures together, that is, 100, 10, & 8, and this muſt be the firſt number in the Rule of proportion; the weight of the Piece the ſecond number, which here is 5600; and the third number is each ſeverall ſort of metal in the mixture, which here be 100, 10, & 8. wherefore by our double lines, this *Quære* is very eaſily reſolved. For,

Set 118, the total of the common mixture on the firſt, to 5600, the weight of the Piece on the ſecond, and then againſt 100 on the firſt, is 4745,7 on the ſecond; againſt 10 on the firſt, is 474,6 on the ſecond, being one place leſs than the former, becauſe 10 is one place leſſe than 100; ſo much Latten is in that Piece: and againſt 8 on the firſt, is 379, 7 on the ſecond, ſo much Tin is in the Gun.

Now if all theſe three ſums thus found be added together, they make the juſt weight of the Piece propounded, as here it doth appear, and proveth the work truly wrought.

4745,7	
474, 6	
379,7	
5600,0	

PRO-

PROBLEM. V.

By knowing what quantity of powder will load some one Piece of Ordnance, to find how much of the same powder will load any other Piece of Ordnance, greater or lesser.

IF a Saker of 3,75 inches Diameter in the Bore, require four pounds of powder for its load, What will a Demi-Canon of 6,5 inches Diameter in the Bore require?

Set 3,75 on the first, to 6,5 on the second, and then against 4, the weight known on the first, is 6,93 on the second, and then against that 6,93 on the first, is 12 on the second; and lastly, against that 12 on the first, is 20,8 on the second, very neer; that is, 20 pounds of powder, and 8 tenth parts of a pound: So much doth the Demi-Canon require.

But note, that it is here understood, that the Demi-Canon ought to be as well fortified as the Saker is, that is, it should bear the same proportion to the Saker in weight and thickness of metal, that the bore thereof beareth to the bore of the Saker, as in this example; The bore of the Saker is 3 inches and 3 quarters, the Cube whereof is 52,73, and its weight is 1600 pounds; The bore of the Demi-Canon is 6 inches and an half, the Cube whereof

whereof is 274,62. Now the queſtion is, How much the weight of that Demi-Canon ought to be, that is proportional in its weight and thickneſſe to the *Saker*, that ſo it may be able to bear a load of powder proportional to the *Saker*.

The weight of ſuch a Demi-Canon is thus found; *Set* 52,37 the Cube of 3,75 on the firſt, to 274,62 the Cube of 6,5 on the ſecond, and then againſt the weight of the *Saker* 1600 on that firſt, is 8351 on the ſecond: The weight that the Demi-Cannon ought to be of, that is proportional in weight to the *Saker*, and able to carry a load of powder proportional to the *Saker*. Or you may work it thus without the Cubes.

Set 3,75 on the firſt, to 6,5 on the ſecond, and then, firſt againſt 1600 on the firſt, is 2766 on the ſecond; ſecondly, againſt this 2766 on the firſt, is 4800 on the ſecond; and thirdly, againſt that 4800 is 8351 on the ſecond, as before: So the one proveth the other.

But if the Demi-Canon be found to want of its proportional weight with the *Saker*, as if it weigh but 6000 pounds, then to find its due load in powder, anſwerable to its ſtrength and weight of metal; Multiply the weight thereof 6000, by 20,8 the charge already calculated, & divide the Product by 8351, the weight it ought

ought to have had, and the quotient is 14,8: Therefore 14 pounds, and 8 tenth parts of a pound, is a sufficient charge for such a Gun.

By our lines, Set 1 on the first, to 20,8 on the second, and then against 6000, is 1248000, the Product. Now set 8351 the Divisor on the first, to 1 on the second, and then against 1248000 on the first, is 14,8 on the second, the quotient sought.

But suppose there be another sort of powder brought to be used, that is stronger than the former, by such proportion as 5 is to 2. How much of this sort will serve to charge that Gun, which required 14,8 pounds of the other sort. For answer of this *Quære*.

Set 5 on the first, to 2 on the second, and then against 14,8 on the first, is 5,9 and a little above: Therefore 5 pounds of powder, and 8 parts of 10 of a pound, of this new sort of powder, will charge the Gun, having as much strength to carry forth the Bullet, as 14 pounds and 8 tenths of the other.

PRO-

PROBLEM. VI.

Knowing how far any Piece of Ordnance will carry her Bullet at point-blank, and at the beſt of her Randon, to find how far any other Piece of Ordnance will carry her Bullet at her beſt Randon, her level-range being known.

A Saker at point-blank conveyes her Bullet 200 paces, and at her beſt Randon 900 paces. Now how far will a Canon carry her Bullet at her beſt Randon, that carrieth it at point-blank 360 paces.

Set 200 on the firſt, to 900 on the ſecond, and then againſt 360, the other Pieces point-blank on the firſt, is 1620 on the ſecond: The number of paces it will carry at point-blank.

If the beſt Randon and point-blank of the one Piece be given, with the beſt Randon of the other Piece, to find the point-blank thereof.

Set 900, the beſt Randon on the firſt, to 200 its point-blank on the ſecond, and then againſt 1620, the other Pieces beſt Randon on the firſt, is 360, its point-blank on the ſecond.

PROBLEM. VII.

By knowing how far any piece of Ordnance will carry a Bullet at the best of her Randon, to find how far she will carry her Bullet at any other degree of Randon.

IF a Piece at her best Randon, which is 45 degrees of Mounture, carry her Bullet 1440 paces, How far will she carry it at 30 degrees of Randon?

Set 45, the best Randon on the first, to 30, the other Randon on the second; and then against 1440, the paces of her carriage at her best Randon on the first, is 960, the paces of her carriage at 30 degrees of Randon; and if you take 960, from 1440, the remain is 480: So much doth she shoot short of her best Randon.

If a Gun carry a Bullet 700 yards at her best Randon, which as aforesaid is at 45 degrees, and the mark to shoot at be distant but 500 yards; To what degree must the Gun be mounted to make a good shoot?

Set 500 on the first, to 700 on the second, and then against 45 on the first, is 63 on the second; or bring 500 to 45, and then against 700 is 63, which is 63 degrees: Therefore the Piece must be raised to 63 degrees of Mounture,

Mounture; to make a good ſhoot into the place.

Note, this queſtion is reſolved by the backward Rule of Three.

If a Gun at her beſt Randon ſhoots 500 yards, How much will ſhe ſhoot ſhort of it, being elevated two degrees above her beſt Randon?

Set 45, the degrees of beſt Randon on the firſt, to 2 the degrees ſhe is elevated above it on the ſecond, and then againſt 500, is 22,22: So many yards will ſhe ſhoot ſhort of her beſt Randon, being elevated 2 degrees above it.

How far is it to the place where a Bullet falleth, the Piece being mounted 15 degrees above her beſt Randon, ſhe abating 22,22 for 2 degrees elevation?

Set 2 on the firſt, to 22,22 on the ſecond, and then againſt 15 on the firſt, is 167 on the ſecond; therefore the Gun being raiſed 15 degrees above her beſt Randon, abateth 167 yards of the 500, her carriage at her beſt Randon, wherefore 167 taken from 500, leaveth 333: So many yards is the place diſtant where the Bullet falleth.

If a Gun ſhoot point-blank 240 paces, and being mounted to one degree, doth out-ſhoot the point-blank 30 paces, What will ſhe out-ſhoot it at 20 degrees of Mounture?

Set

Set 1 on the firſt, to 30 on the ſecond, and then againſt 20 on the firſt, is 600 on the ſecond: So many paces will ſhe out-ſhoot her point-blank, being mounted 20 degrees, in the whole ſhot 840 paces.

PROBLEM. VIII.

To find out how much wide of the mark any Piece of Ordnance will ſhoot, by knowing how far it is to the mark ſhot at, and how wide the Pieces mouth lieth from the right line to the mark.

A Gun of 10 foot, or 120 inches long, being to ſhoot at a mark 700 yards diſtant, her mouth lying one inch beſide the right line to the mark, How far will ſhe ſhoot her Bullet wide of the mark at that diſtance?

For anſwer: Firſt, bring 700 yards into inches, and they make 25200, which is done by Multiplication thus;

Set 1 on the firſt, to 36 on the ſecond, for that is the number of inches in a yard, and then againſt 700, the diſtance on the firſt, is 25200, the inches in 700 yards. And then,

Set 120 on the firſt, the Guns length in inches, to 1; and then againſt 25200, the diſtance in inches, is 210 inches, or 17 foot and an half: So far the Bullet goeth wide of the mark.

PRO-

PROBLEM. IX.

Knowing the quantity of each ſort of Ingredients for the making of Gun-powder, to find how much of every ſort is to be put into any quantity of powder that ſhall be required to be made.

I Have read in ſome Authours, that for making of the beſt ſort of ordinary Gun-powder, there is uſed to be taken 12 parts of Mercury, three parts of Cole, and two parts of Sulphur, in all 17 parts. Now a Gun-powder-maker is appointed to make 1000 pound weight of powder, How much muſt he take of each ſort of theſe Ingredients, to make that quantity of powder?

Set 17, the ſum of the parts on the firſt, to 1000, the quantity to be made, on the ſecond; and then without more ado, on the firſt, right againſt 12 is 706, and againſt 3 is 176,5; and laſtly againſt 2 is 117,5 on the ſecond. Theſe three ſums being added together, make juſt 1000. Therefore you may conclude, that to make 1000 pounds of Gun-powder, he muſt take of Mercury 706 pounds, of Cole 176,5, and of Sulpher 117,5 pounds the thing required. This Problem is grounded upon the rule of Proportion thus:

As 17, the whole parts taken,
Is to 1000 the quantity to be made:
So is each several part of the mixture.
To the quantity thereof to be taken towards the making of 1000 weight.

I might have put down the Analogies of Proportion all along, as I did at the beginning; but I thought those things would have filled my book too fast, and every man that knowes the rule of Proportion, cannot but see how every Problem is resolved thereby.

CHAP.

CHAP. VII.

The Use of the double Scales in Fortification.

THe side of a Pentagonal Fort being propounded, with the perpendicular, and all the other lines, with the Area; To find the sides and all other lines and Content of any other Pentagonal Fort, that shall be required to be made, either greater or lesser, according to any proportion assigned.

Suppose there be a Pentagonal Fort made, such an one as is represented by this Diagram annexed, noted by the letters A B S T X K O G F E D N M L H P and C, whose sides A B, B S, S X, X R, and K A, are each 662 yards, And let it be required; to make another Fort that shall be a just fourth part in Content of ground of that propounded Fort. Now the Content of the propounded Pentagonal Poligon, described by the letters A B S X K, is 754680 yards, and the sides and lines of the Fort thereon made are as followeth,

The side of the Pentagon A B, is 662 yards.

The Perpendicular C I, 456 yards.

The Semidiameter of the Pentagon C A, 564 yards.

The Gorge-lines of the Fort A D, A O, N B, B P, each one of them 119 yards.

The Flanks of the Bulwark D E, O G, 100 yards.

The Curtain D N, 424 yards.

The Fronts lines F E, F G, and L M, L H, 264 yards.

The Head-lines, or Capital A F, or B L, 224 yards.

The breadth of the Bulwark from G to E, or M to H, 330 yards.

The Lines of Defence D L, and N E, 700 yards.

The distance between the points of the Bulwark F and L, is 926 yards.

The Line perpendicular to the Line F L, *viz.* C R, 637 yards.

By these Lines and lengths known, it is required to make another Pentagonal Fort, whose quantity or Content in land shall be the just fourth part of the proposed Pentagonal Fort propounded: where note, that the half of the sides and lines of the Fort made will make another Fort, that will contain the fourth part of the ground in that Fort made: And that you may readily have half of all the lines of the Fort made, do thus:

Set

Set 2 on the first, to 1 on the second, and then against the number of any line on the first, is its half on the second: As against 662, the length of the side of the Pentagon given, is 331, the length of the Pentagons side to be made. The Lines thus remaining without any moving, against 119 on the first, the length of the Gorge-line in the made Fort, is 59,5, the length of the Gorge-line in that Fort to be made: And against 424, the length of the Curtain in the made Fort, is 212 on the second the length of the Curtain in that Fort to be made: And against 456, the length of the proposed Poligons perpendicular which is made, is 228, the length of the perpendicular in that Poligon which is to be made: And against the Semidiameter 564, is 282: And against 100, the length of the present Bulwarks flank, is 50, the length of the Flank in the Bulwark to be made. And against 224, the length of the Bulwarks head-line, is 112, the length of the head-line in the Fort to be made: And against 310, the distance of the shoulders G E, or M H in the Fort made, is 155, for the distance of the shoulders in that Fort which is to made: And in like manner, against the length of any Line in the proposed Fort is the length of that same Line in the Fort to be made.

Thus very speedily is found out the true

length of all the Lines in and belonging to such a Fort as is required to be made, whose lines and sides shall be just half the length of those in the Fort already made: And being drawn on the ground, and made up, will in all parts be like & proportional to the same proposed Fort. The like manner of working is to be used for any other proportion whatsoever, either greater or lesser.

Suppose it were required to make a Pentagonal Fort, whose sides, and so all the lines thereof, should be the one third part in length of the sides and lines in that proposed Fort, which in the annexed Diagram is represented by the letters C A B S T X K O G F E D N M L P H. To which demand, to give a ready answer, do thus:

Because one third part is sought for, Set 3 on the first, to 2 on the second, and then against 662 on the first, the side of the Pentagon given, is 220⅔ on the second, which is one third part of 662, & sheweth that the length of the side of the Pentagon to be made is 220⅔ yards; and against 119, the length of the Gorge-lines in the proposed Fort, is 39⅔, that is 39 yards 2 foot, which is the third part of 119, and is the just length of the Gorge-lines in the Fort to be made. In like manner, against any Line or distance in the proposed Fort; is the length

of

of the ſame Line in that fort to be made. For to be ſhort, Take any number on the firſt, and right againſt it on the ſecond, is the one third part thereof.

How to make a Fort greater than the Fort propoſed.

SUppoſe there be a fort made, ſuch an one as is that repreſented in the afore-mentioned Diagram, and another Fort is to be made like to it; ſo that in all the lines and ſides thereof, it be double to thoſe in the Fort that is already made.

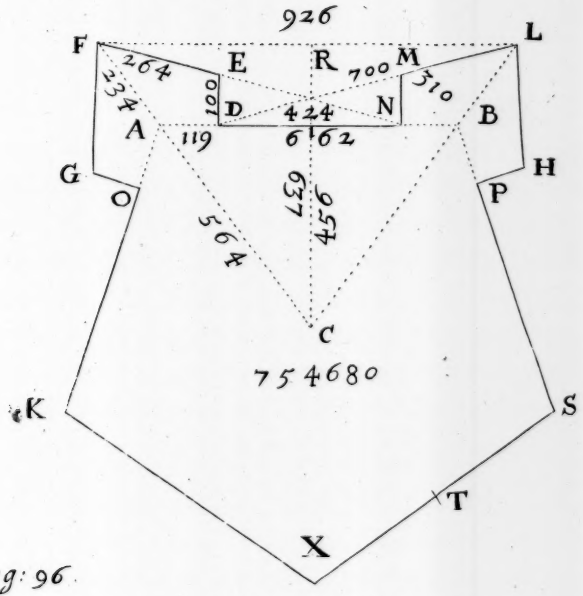
In this caſe and the like, we have no more to do, but to ſet 1 on the firſt, to 2 on the ſecond, and then againſt the number of the length of any ſide or line on the firſt, is the double of it on the ſecond. As if you ſet 1 on the firſt, to 2 on the ſecond, then againſt 456 on the firſt, the length of the perpendicular in the Pentagonal Fort given, you ſhall have 912 on the ſecond, the double of 465, which is the length of the perpendicular in that Fort to be made; and againſt 662, the length of the Curtain in the Fort made, is 1322, the length of the Curtain in the Fort to be made: And ſo of all the reſt of the Lines.

If it ſhall be required to make ſuch a Fort, as in its ſides and lines ſhall be one third part longer than thoſe in the propoſed Fort: Then

take any one line, as for example, C I 456 yards, and thereof take the one third part, which is 152: This add to the same 456, and it makes 608. This done, Set 456 on the first, to 608 on the second, and then against any line of the Fort made on the first, it its match-line in the Fort to be made: As against D N, the Curtain in the made Fort, 424 yards, is 565⅓: So many yards will the Curtain be in that Fort to be made, and so of all other lines. And if a Fort be to be made, whose sides and lines must be half so much more in length, as are the sides and lines of the proposed Fort: Then take the half of any number, and add it to the same number, and so proceed as before.

Note, that the lines in the Type or Diagram annexed, may be accounted in their lengths there sat down, either so many foot, or so many yards, or so many perches, or what other measure you are to use: And so the side of the Pentagon 662, may be accounted 662 yards, or 662 foot, or 662 perches. Thus by supposing a Pentagonal Fort to have lines and sides in length, as those in the Diagram, you may by these double lines very easily discover all the lines and sides of any other Pentagonal Fort, either greater or lesser.

CHAP.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CHAP. VIII.

The Use of the double Scale of Sines in Astronomy.

PROBLEM. I.

The Suns greateſt declination, with his place or diſtance from the next Equinoctial point being given, to find his preſent declination for the time given.

THe Suns greateſt declination in this our age, is found to be 23 degrees 30 minutes. This is general, his place given on the day propoſed, is 0 degrees of *Taurus*, which point is diſtant from the next Equinoctial point of *Aries* 30 degrees.

The Analogie for Solution of this Propoſition is thus:

As the Radius, or Sine of 90 degrees, Is to the Suns greateſt declination 23 deg. 30 min.

So is the diſtance of the Sun 30 deg. from the next Equinoctial point which is *Aries*, To the Sine of the declination 11 degr. 30 min. ſought for. Wherefore,

Set 90 degrees on the firſt, to the Suns greateſt declination 23 deg. 30 min. on the ſecond, and

and then against 30 deg. the Suns distance from the next Equinoctial point on the first, is 11 deg. 30 min. on the second: So much is his declination sought for, his place being the very beginning of *Taurus*.

Suppose the Sun be in the beginning of *Leo*, which is 60 degrees distant from the Equinoctial point of *Libra*; then set 90 deg. on the first, to 23 deg. 30 min. on the second, and then against 60 deg. on the first, is 20 deg. 10 min. on the second: The declination of the Sun, when he is entring into *Leo*.

PROBLEM. II.

The Suns greatest declination, and his present declination for any time proposed being had, to find his distance from the next Equinoctial point, and thereby his place in the Ecliptick.

SEt the Suns greatest declination, 23 deg. 30 min. on the first, to 90 degrees on the second; and then against his present declination, being given 11 deg 30 min. on the first, is 30 degrees on the second: So much is his distance from the next Equinoctial point, which is *Aries*; therefore his true place is just leaving *Aries*, and entring *Taurus*.

Again, suppose the Suns present declination be given 20 deg. 10 min. and his place sought:

Set

Set 23 deg. 30 min. on the first, to 90 deg. on the second, and then against 20 deg. 10 min. on the first, is 60 degrees on the second: So much is the Suns distance from the next Equinoctial point.

Now if the Sun be in the first quarter of the Ecliptick, between *Aries* and *Cancer*, then he is distant from the Equinoctial of *Aries* 60 degrees, and therefore in the beginning of *Gemini*: But if he be in the second quarter of the Ecliptick, as in this proposal he is, his distance is to be accounted from the Equinoctial of *Libra*, and then his place must be in the beginning of *Leo*; If he be in the third quarter of the Ecliptick, and 60 degrees from the next Equinoctial point, then he is in the beginning of *Sagittarius*: And if he be in the fourth quarter of the Ecliptick, and distant 60 degrees from the next Equinoctial point, then he must be in the beginning of *Aquarius*.

PROBLEM. III.

The Suns declination, and the Latitude of the place being given, to find the Suns Amplitude.

LEt be given the Suns declination, 11 deg. 30 min. and the Latitude of the place proposed 51 degrees 30 minutes, whose Complement to 90 degrees, is 38 degrees, 30 minutes:

nutes: And the Amplitude ſought for.

Set the Co-ſine of the Latitude 38 deg. 30 min. on the firſt, to the Radius, or 90 degrees on the ſecond, and then againſt the ſine of the Suns declination, 11 deg. 30 min. on the firſt, is 18 deg. 40 min. on the ſecond: So much is the Suns Amplitude, at ſuch time as his declination is 11 deg. 30 minutes. Or,

Suppoſe the Suns, or a Stars declination were known to be 20 degrees, then without altering the lines from the place they were firſt ſet to, right againſt 20 deg. on the firſt, is 33 deg. 10 min. on the ſecond, the Amplitude ſought: And ſo againſt any other declination on the firſt, is the Amplitude on the ſecond.

PROBLEM. IV.

The Latitude of the place, the Suns greateſt declination with his diſtance from the next Equinoctial point being had, to find his Amplitude.

THe Latitude is 51 deg. 30 min. whoſe Complement is 38 deg. 30 min. the Suns diſtance from the next Equinoctial point is 18 deg. 40 min. and his greateſt declination 23 deg. 30 min. and the Amplitude required.

Set the Co-ſine of the Latitude, 38 deg. 30 min. on the firſt, to 23 deg. 30 min. on the ſecond, the ſine of the greateſt declination, and then

then againſt 30 degrees, the diſtance from the neereſt Equinoctial point on the firſt, is 18 deg. 40 min. on the ſecond: So much is the Suns Amplitude, when his place is in the beginnings of *Taurus*, *Virgo*, *Scorpio*, or *Piſces*.

PROBLEM. V.

The Latitude of the place, the Suns place or diſtance from the next Equinoctial point, with his greateſt declination being known; to find what altitude the Sun will have, when he is on the true Eaſt or Weſt point.

LEt the Latitude be 51 deg. 30 min. the Suns place in 10 degrees of *Taurus*, which is diſtant from the next Equinoctial point 40 degrees, and the greateſt declination 23 deg. 30 min. What is the Suns altitude at the true Eaſt or Weſt point?

Set 51 deg. 30 min. on the firſt, (the Latitude of the place) to 23 deg. 30 min. the greateſt declination on the ſecond; and then againſt 40 degrees, the diſtance from the neereſt Equinoctial point on the firſt, is 19 degr. 5 min. on the ſecond: So much is the Suns altitude, when he is on the true Eaſt or Weſt point: And at his entrance into *Taurus*, his altitude at that point is 14 degrees 45 minutes. As this, ſo his altitude for any other place is found,

found, without ſtirring the lines, after once ſet together.

PROBLEM. VI.

The Latitude of the place, and Suns declination being had; to find what altitude the Sun will be of, when he cometh upon the true Eaſt or Weſt point.

LEt the Latitude be 51 deg. 30 min. and the Suns declination 11 deg. 30 min. and his height at his being on the due Eaſt or Weſt point required.

Set the ſine of the Latitude, 51 deg. 30 min. on the firſt, to the Radius on the ſecond, and then againſt the ſine of the given declination, 11 deg. 30 min. on that firſt, is 14 degr. 45 min. on the ſecond. So much is the Suns altitude at the time of his being due Eaſt or Weſt, when his declination is 11 deg. 30 min.

PROBLEM. VII.

Having the Suns greateſt declination, and his diſtance from the next Equinoctial point; to find his right aſcenſion.

THe Suns greateſt declination is 23 degr. 30 min. and his place given is 0 degr. of *Taurus*. Therefore his diſtance from the neereſt Equi-

Equinoctial point *Aries* is 30 degrees: By these known, his right Ascension is desired.

Set 90 deg. on the first, to the Co-sine of the greatest declination, 66 deg. 30 min. on the second; and then on the back-side, (being the lines of *Tangents*) against the *Tangent* of 30 degrees, the Suns distance from the neerest Equinoctial point on that first, is the *Tangent* 27 degr. 50 min. So much is the Suns right ascension at that time.

PROBLEM. VIII.

The Suns greatest declination, and his present declination, being given for a time; to find his right ascension for that time.

THe Suns greatest declination is 23 degr. 30 min. and his present declination for a time proposed, is 11 deg. 30 min. I demand his right ascension thereby.

Set the *Tangent* of 23 deg. 30 min. on the first, to the *Tangent* of the present declination, 11 deg. 30 min. on the second; and then upon the other side, on the lines of sines, against the Radius on the first, is the sine of 27 degr. 50 min. on the second: So much is the Suns right ascension demanded.

PRO-

PROBLEM. IX.

The Latitude of the place, and the Suns declination known; to find how long the Sun riseth and setteth, before or after the hour of six.

THe Latitude of the place is 51 degrees, 30 minutes North, and the Suns declination, 11 degrees, 30 minutes. I demand the time of Sun-rising before six.

Set the Co-tangent of the Latitude, 38 deg. 30 min. on the first, to the Tangent of 11 deg. 30 min. the declination given on the second; & then on the other side, against the Radius on the first, is the sine 14 deg. 50 min. This 14 deg. 50 min. converted into time, by accounting four minutes of an hour to every degree, and one minute of an hour for 15 minutes of a degree, and it will amount to 59 minutes of an hour: So long the Sun riseth before six in the morning, and sets after six at night in the Summer season; and in the Winter season, or Southern signes, he riseth so long after six in the morning, and sets so long before six at night, where the Latitude is 51 deg. 30 minutes, and when the Suns declination is 11 deg. 30 min. South.

PRO-

PROBLEM. X.

The Sun being in the Equinoctial, by knowing his distance from the Meridian, and the latitude of the place; to find the Suns altitude at that time.

MArch the tenth, the Sun being in the Equinoctial at ten a clock before noon, or at two a clock after noon, he being at that hour distant from the Meridian 30 degrees, I would know his height in our Latitude of 51 deg. 30 minutes.

Set the Radius on the first, to the Co-sine of the Latitude, 38 deg. 30 min. on the second, and then against the Co-sine of the Suns distance from the Meridian, *viz.* against 60 degrees on the first, is 32 deg. 37 minutes on the second; So much is the Suns altitude on the tenth of March, at ten a clock in the fore-noon, and at two a clock afternoon.

PROBLEM. XI.

The Latitude of the place, and the Suns declination Northwards being known; to find the Suns altitude, at the hour of six.

LEt the Latitude of the place be 51 deg. 30 min. the Suns declination 11 deg. 50 min.

North: And the Suns height at six a clock is desired.

Set the Radius on the first, to the sine of the declination, 11 deg. 50 min. on the second; and then against 51 deg. 30 min. the Latitude on the first, is 8 deg. 58 min. on the second: So much is the Suns height at the hours of six, at morning and night. Or else thus:

Set the Radius to 51 deg. 30 min. and then against 11 deg. 50 min. on the first, is 8 degrees 58 minutes on the second: For note, that the Radius on the first may be set to either of the other two terms given on the second, and then against the other term on the first, is the answer on the second.

PROBLEM. XII.

The Latitude and declination of the Sun being known; to find the Suns Azimuth at the hour of six, from the North part of the Meridian.

IN the Latitude of 51 deg. 30 min. the Suns declination given is 11 deg. 30 min. What is his Azimuth at the hour of six?

Set the Radius on the first, to the Co-sine of the Latitude, 38 degr. 30 min. on the second; and then against the Co-tangent of the declination, 11 deg. 30 min. on the first, is the Tangent 82 deg. 47 min. on the second: So much

much is the Suns Azimuth from the North towards the East, which was required.

PROBLEM. XIII.

The Latitude of the place, and the Suns altitude at the point of his being due East or West; to find the hour and minute when he will be so due East or West.

THe Latitude of the place is 51 degrees, 30 min. The Suns height found at his being on the true East point, is 14 deg. 45 min. I demand the hour of the day.

Set the Radius on the first, to the Co-sine of the Latitude, 38 deg. 30 min. on the second; and then on the Lines of Tangents, right against the Tangent of the Suns altitude, at his being due East, *viz.* 14 deg. 45 min. on that first, is 9 deg. 18 min. on the second, the Tangent of time from the hour of six, either before or after, that the Sun will be due East, or due West. This 9 degr. 18 minutes reduced into time, by allowing to every degree four minutes of time, and for fifteen minutes of a degree, one minute of time, amounteth to 37 minutes of time: So then the Sun is due East on the day given, at 37 minutes after six a clock in the morning; and also will be

due West at 36 minutes before six at Night, which is at five a clock 23 minutes.

PROBLEM. XIV.

The elevation of the Pole, the Suns (or a Stars) declination, and distance from the Meridian for any time being given; to find the Suns altitude at that time.

LEt the elevation of the Pole be 51 deg. 30 min. whose Complement to 90, is 38 deg. 30 min. The Suns declination 11 deg. 30 minutes, whose Complement is 78 deg. 30 min. his distance from the Pole; his distance from the Meridian 30 degrees, or which is all one, two hours, that is, either at ten or two a clock, and the Complement of this distance to 90 degrees, is 60 degrees: And let the Suns Altitude for that time be required.

1 Set the Radius on the first, to 60 deg. the Co-sine of the Suns distance from Noon on the second; and then on the lines of Tangents against 38 deg. 30 minutes, the Co tangent of the elevation on the first, is the Tangent 34 degrees, 33 min. on the second; for the fourth term, which taken from the Suns distance from the Pole, the Remainder is 43 degrees, 56 minutes.

2 Set

2 Set the Co-sine of that 34 deg. 33 min. the fourth term, *viz.* 55 deg. 27 min. on the first, to 46 deg. 4 min. the Co-sine of that Remainder on the second; and then against the sine of the Elevation, 51 deg. 30 minutes on the first, is the sine 43 deg. 18 min. on the second: So much is the altitude of the Sun at that time, the thing required.

This is when the Sun hath Northern declination, but when he hath Southern declination, then add his declination to 90 degrees, and it makes 101 deg. 30 min. the Suns distance from the Pole, from which take the fourth term found, and the Remain is 66 deg. 27 min. This done, the second work would be thus:

Set the Co-sine of the fourth term found on the first, *viz.* 55 deg. 27 min. to the Co-sine of that Remain, which is 23 deg. 33 min. on the second; and then against 51 deg. 50 min. the Elevation on the first, is 21 deg. 52 minutes on the second. The Suns height at ten or two a clock, when he hath 11 degrees 30 minutes of South declination.

If the Sun be just in the Equinoctial, having no declination; then to find his height on that day at ten or two a clock, the work will be done at one working in this manner.

Set the Radius on the first, to 60 degrees, the Co-sine of the distance from the Meridian,

on the second; and then against 38 degrees, 50 min. the Co-sine of the Elevation on the first, is the sine 32 deg. 62 min. So much is the Suns altitude at the hours of ten and two a clock on the Equinoctial day.

PROBLEM. XV.

Having the Poles elevation, and the Suns declination; to find the ascensional difference.

LEt the Poles elevation be 51 deg. 30 min. and the Suns declination 11 deg. 30 min. And by them the ascensional difference required to be given.

Set 38 deg. 30 min. the Co-tangent of the elevation on the first, to the Tangent of the declination 11 deg. 30 min. on the second; and then (on the Lines of Sines) against the Radius on that first, is the sine of 14 deg. 49 min. on the second: So much is the ascensional difference required at that time, as the Sun hath 11 deg. 30 min. declination.

I could shew by this ascensional difference converted into time, How to find the time of Sun-rising and setting, with the length of day and night, &c. But these are things done without the Lines, and therefore I passe them by, having limited my self to shew only the use of the double Lines.

PRO-

PROBLEM. XVI.

Having any Planets declination and Latitude, with its distance from the next Equinoctial point; to find its right ascension.

LEt a Planets declination be 26 degrees, its Latitude 4 degrees, and its distance from the neareſt Equinoctial point 70 degrees, (it being in the 10 degree of *Gemini*) I demand the right aſcenſion thereof: which to attain,

Set 64 deg. the Co-ſine of the declination, to 20 deg. the Co-ſine of the Planets diſtance from the next Equinoctial point; and then againſt 86 deg. on the firſt, the Co-ſine of the Planets latitude, is 22 deg. 17 minutes on the ſecond, the Co-ſine of the right aſcenſion: Therefore 67 deg. 43 min. (being the Complement of 22 deg. 17 min) is the right aſcenſion of that Planet which was demanded.

PROBLEM. XVII.

The Suns greateſt declination, with his diſtance from the next Equinoctial point, being had; to find the Meridian angle, that is, the interſection of the Meridian with the Ecliptick.

LEt the Suns greateſt declination be 23 deg. 30 min. and his place juſt entering *Taurus*,

which is distant from the neareſt Equinoctial point 30 degrees, I would know the Meridian angle.

Set the Radius on the firſt, to 60 degrees, the Co-ſine of the Suns diſtance from the neereſt Equinoctial point on the ſecond; and then on the lines of Tangents, againſt 23 deg. 30 min. the Tangent of the Suns greateſt declination on the firſt is 20 deg. 38 min. on the ſecond, which is the Co-tangent of the angle ſought: Wherefore the Meridian angle is 69 deg. 22 minutes, being the Complement of 20 degrees, 38 minutes, to 90 degrees.

PROBLEM. XVIII.

The Suns declination and amplitude given, to find the heighth of the Pole.

LEt the Suns declination given be 14 degr. 51 min. and his amplitude 19 deg. 7 min. And the Poles elevation demanded.

Set 19 degr. 7 min. the amplitude on the firſt, to 14 deg. 51 min. the declination on the ſecond; and then againſt the Radius on the firſt, is 51 deg. 30 min. on the ſecond, which is the line of the latitude: Wherefore 51 deg. 30 min. is the Latitude ſought.

PRO-

PROBLEM. XIX.

The amplitude of the Sun, and time of his rising being known; to find thereby his declination.

LEt the Suns amplitude be 33 degr. 38 min. and the time of his rising be at 4 a clock 10 minutes; by which two things known, I would find the declination of the Sun. Here first convert the 4 hours 10 minutes into degrees and minutes, and they make 62 degr. 30 minutes.

Now set this 62 degr. 30 min. the time of Sun-rising converted into degrees on the first, to 56 deg. 22 min. the Co-sine of the amplitude on the second; and then against the Radius on the first, is 69 degr. 50 min. on the second, the Co-sine of the declination: Whereby it followeth, that 20 deg. 10 min. is the declination desired.

PROBLEM. XX.

Having the elevation of the Pole, and the Suns amplitude; to find his declination.

LEt the Elevation of the Pole be 51 degr. 30 min. and the Suns amplitude 19 deg 7 min. By which two things given, the declination is required.

Set

Set the Radius on the first, to 19 deg. 7 min. the Suns amplitude on the second, and then against 51 deg. 30 min. the sine of the elevation on the first, is 14 deg. 51 min. the sine of the declination upon the second: The thing desired.

PROBLEM. XXI.

Having the hour of the day, the Suns altitude and declination; to find the Azimuth.

LEt the Suns altitude be 25 degr. 56 min. whose Complement is 64 deg. 4 min. his declination 11 deg. 30 min. whereof the Complement is 78 degr. 30 min. The hour of the day, 7 hours 56 minutes fore noon, which time is distant from noon 4 hours 4 minutes. This time converted into degrees, giveth 61 degrees. Now by these things known, the Azimuth is desired to be found.

Set 64 degrees 4 minutes, the Co-sine of the Suns altitude on the first, to 61 degrees, the Suns distance from the Meridian on the second; and then against 78 degrees 30 minutes, the Co-sine of the declination on the first, is 72 degrees 22 minutes on the second, So much is the Suns Azimuth from the South Eastwards.

PRO-

PROBLEM. XXII.

The Suns declination, altitude, and azimuth being known; to find the hour of the day.

SUppoſe the Suns declination be 11 degr. 30 min. his altitude 25 deg. 56 min. and the Azimuth 72 deg. 22 min. Hereby to find the hour of the day.

Set 78 deg. 30 min. on the firſt, (which is the Complement of the declination) to 64 deg. 4 min. on the ſecond, which is the Complement of the Altitude; and then againſt 72 deg. 22 min. the Azimuth on the firſt, is 61 degr. on the ſecond. This 61 degrees converted into time, giveth 4 hours 4 minutes, which taken from 12 hours, the Remain is 7 hours 56 minutes before noon, the time of the day required.

PROBLEM. XXIII.

The altitude of the Equator, and the Suns, or a Stars declination being given; to find the angle of the Meridian with the Horizon.

LEt the altitude of the Equator be 51 degrees 30 minutes, and the declination 22 degrees. And the angle of the Meridian with the Horizon ſought for.

Set

Set 68 degrees, the Co sine of the declination on the first, to the Radius on the second; and then against 51 deg. 30 min. the Co-sine of the Equators altitude, on the first, is 57 degrees 34 minutes on the second: So much is the angle of the Meridian (or circle of Declination) with the Horizon.

CHAP.

CHAP. IX.

The Use of the double Scales in Geography.

PROBLEM. I.

Two places lying without the Equinoctial, and having both one Latitude; differing onely in Longitude, being propounded; to find their Distance.

SUppose there be two places, lying both in the Latitude of 48 deg. 20 min. differing onely in Longitude 16 degrees, as do *Paris* in *France*, and *Vienna* in *Austria*, whose distance is desired.

Set the Radius on the first, to 41 degrees 40 minutes, the Co-sine of the Latitude on the second; and then against 16 degrees on the first, the difference of Longitude, is 10 degrees 36 minutes, which in miles makes 636: So much is the distance between the two places.

PRO-

PROBLEM. II.

Two places being propounded, which differ in Longitude, the one lying under the Equinoctial and the other having Latitude, to find their distance in miles.

LEt two places be propounded, the one lying under the Equinoctial, having 313 degrees of Longitude, and the other lying in the Latitude of 32 deg. 42 min. and in the Longitude of 323 degrees, they differing in Longitude 10 degrees, I would know their distance.

Set the Radius on the first, to 80 degrees on the second, the Co-sine of the difference of Longitude; and then against 57 deg. 18 min. the Co-sine of the one places Latitude on the first, is 55 deg. 58 min. the Co-sine of the distance in degrees; the Complement of this 55 deg. 58 min. to 90, is 34 deg. 2 min. which converted into English miles, giveth 2042 miles: So much is the distance between the two places.

PRO-

PROBLEM. III.

Two places having ſeveral Latitudes towards one Pole, and differing in Longitude; to find their diſtance.

LEt *London* and *Jeruſalem* be two places propounded, betwixt which the diſtance is required: The Latitude of *London* is 51 degrees 30 minutes, the Latitude of *Jeruſalem* is 32 degrees; and their difference in Longitude is 47 degrees. Now to find their diſtance.

1 Set the Radius on the firſt, to 43 degrees the Co-ſine of the difference of Longitude on the ſecond; and then on the lines of Tangents againſt the Co-tangent of the greater Latitude, 38 degees, 30 min. is 28 deg. 28 min. on the ſecond; the fourth term. This fourth term, 28 deg. 28 min. taken out of the Complement of the leſſer Latitude, that is here, out of 58 deg. the Remain is 29 deg. 32 min. Then,

2 Set 28 deg. 28 min. the fourth term found, to that Remain, 29 deg. 32 min. on the ſecond, and then againſt the Co-ſine of the greater Latitude, *viz.* 38 deg. 30 min. is the ſigne 39 deg. 14 min. the diſtance ſought for in degrees of a great Circle, which converted into miles, makes 2354 miles, the diſtance between *London* and *Jeruſalem*.

PRO-

PROBLEM. IV.

Two places, one having North Latitude, and the other South Latitude, and differing in Longitude; to find their distance.

Suppose the one place be in 50 degrees of North Latitude, and the other in 32 degr. 25 min. of South Latitude, and their difference in their Longitude 70 degrees, and betwixt these two such places, the distance is desired. To resolve this demand:

1 Set the Radius on the first, to 20 degrees the Co-sine of the difference of Longitude on the second; and then against 50 degres, the Tangent of the greater Latitude, is the Tangent 16 degrees 1 minute, a fourth term. This fourth term, 16 degrees 1 minute, take from 57 degrees 35 minutes, the Complement of the lesser Latitude, and the Remain is 41 degrees 34 minutes, for a fifth term. Now then:

2 Set 73 degrees 59 minutes the Complement of 16 degrees 1 minute, the fourth term, to 48 degrees 26 minutes, the Complement of that 41 degrees 34 minutes, the fifth term; and then against the sine, the greater Latitude 50 degrees on the first, is the sine 36 degrees 36 minutes, whose Co-sine 73 degrees 24 minutes,

nutes is the distance in degrees by a great Circle. This 53 deg. 24 min. being turned into miles, by multiplying by 60, maketh 3204 miles, and in leagues 1068: So much is the distance sought for between the two places.

CHAP.

CHAP. X.

Of plain right lined Triangles.

PROBLEM. I.

In a plain right lined Triangle, right angled, the three angles being known, and one side; to find either of the other sides.

IN the Triangle annexed A B D, let the angle at A be a right angle, or 90 degrees, the angle at D. 43 deg. 20 min. and the angle at B. 46 deg. 40 min. and the side A B 230 yards; and let the side A D be the side sought.

The Resolution of this Problem upon the Instrument is by this Analogie:

As the Sine of the Angle opposite to the side known,
Is to the Sine of the Angle opposite to the side required:
So is the side known,
to the side sought.
And therefore in this Example it is,

As the sine 43 deg. 20 min. the angle at D opposite to A B the side known, is to the sine of the angle at B, 46 deg. 40 min. which is the angle opposite to the side sought A D: So is the

the length of the known side A B 230 yards, to 243 yards and very near three quarters of a yard, the length of the side A D, which was required. Wherefore,

Upon the lines of sines, Set the sine 43 deg. 20 min. on the first, (the angle at D. opposite to the side given.) To the sine 46 deg. 40 min. on the second, (which is the sine of the angle opposite to the side required.) And then upon the lines of Numbers, against 230, the length in yards of the known side on that first, is 243 and three quarters very neer: So then the length of the side A D, which is sought, is 243 yards, and very near three quarters.

For further illustration hereof; Suppose you were standing at A, and would know how far it is from you to some notable mark, as to D. Here first erect some Mathematical Instrument, as the *Theodilit*, or some other at A, the place of your standing; and by help thereof, let a mark be set up side-ways, (which way the ground will be best for the purpose) as at B, in a line making right angles with the visual line from you at A to D; this done, measure from A to your mark B, and find it 230 yards. Then place your Instrument at B, and observe the angle there as A B D, which find 46 degr. 40 min. this angle had, and the other at B being a right angle, the angle at the mark D must needs

be 43 deg. 20 min. being the Complement of the angle observed at B to 90 degrees: These things had, the work by my Instrument is the same, as is afore shewed. For,

Set 43 deg. 20 min. on the first, to 46 deg. 40 min. on the second; and then upon the lines of Numbers, against the measured length 230 on the first, is 243,7 & better on the second: So then the distance from you to the mark is 243 yards, and something better than seven tenths of a yard, which is very near 3 quarters. If you please to work this Example by the Tables of Logarithms, you shall find the work of the Instrument to agree most notably with that of the Tables.

I might have placed the Problems of right lined Triangles after those of Spherical; for that these require to be resolved by the lines of Sines Tangents and Numbers together, whereas those of Spherical Triangles are resolved only by lines of Sines and Tangents alone, and therefore require the more variety: but the doctrine of plain Triangles being usually first taught, I have therefore first placed it; and the rather, because by these Problems of right lined Triangles, you may see the way to work with both the lines of Numbers, Sines, and Tangents altogether, in any case whatsoever.

PRO-

PROBLEM. II.

In a plain right lined Triangle oblique angled, the three angles and one side being known; to find either of the other sides.

IN the Triangle C B D, let the obtuse angle at C be 112 deg. 0 min. the angle at D be 43 deg. 20 min. and the angle at B 14 degr. 40 min. and let the known side be C D 100 pole, and let the side C B be the side sought.

The Analogy for resolution of the present Problem, is the same as in the former, wherefore it is;

As 14 deg. 40 min. the angle opposite to the side known,
Is to 43 deg. 20 min. the angle opposite to the side sought;
So is 100, the length of the side known,
To 271 the length of that side sought.

Therefore, upon the lines of Sines, Set the sine 14 deg. 40 min. on the first, to 43 deg. 20 min. the sine of the angle opposite to the side required on the second; and then upon the lines of Numbers, against 100 on the first, is 271 on the second: So much is the length of that side sought. For a further illustration:

Suppose you were standing at C, and desired to know how far it is from you to B. Here

by reason of some impediment, as a pond, a wall, a hedge, or some other thing, you cannot point out your second station at right angles with the visual line from C to B, but are inforced to work by an angle greater than a right angle; wherefore at C observe an angle, as B C D of 122 degrees, and measure along from C to D 100 pole, and at D observe the angle C D B 43 deg. 20 min. These two angles had, add them together, and they make 165 degr. 20 min. which taken from 180 degrees, leaveth 14 deg. 40 min. for the angle at B. (For in all Triangles, if any two of the angles be known, the third is also known, for it is evermore the Complement of them both to 180 degrees.) These things thus had, the Analogy for resolution of the *quære* by the lines, is the same as before. Therefore,

Set the sine 14 deg. 40 min. on the first, (the sine of the angle opposite to the side known) to the sine 43 degr. 20 min. (the sine of the angle opposite to the side required) on the second; and then on the lines of Numbers, against 100, the length of the side known on the first, is 271 on the second: Therefore 271 pole is the length, or distance of B, the mark from your station C, which was desired.

PRO-

PROBLEM. III.

If two ſides of a right lined Triangle, and an Angle oppoſite to one of them ſides being known; to find the angle oppoſite to the other ſide.

HEre the Analogy ſtandeth thus by the Lines.

As that ſide oppoſite to the angle known,
Is to the other known ſide;
So is the known angle,
To that angle ſought.

Example. In the Triangle B C D, let the one ſide known be the ſide C D, 100 yards; and the other ſide known be C B, 271 yards; and let the angle at B. be known to be 14 deg. 40 min. and let the angle at D be ſought.

Upon the lines of Numbers; Set 100, the ſide C D oppoſite to the known angle B on the firſt, to 271 the ſide C B oppoſite to that angle at D ſought for on the ſecond; and then on the lines of Sines, againſt the ſine of the known angle 14 deg. 40 min. on the firſt, is 43 degr. 20 min. on the ſecond: So much is the quantity of the angle D, which was ſought.

PROBLEM. IV.

Two sides, and the angle included between them, being a right angle; to find the other two angles.

IF you would find the lesser of the two unknown angles; Then the Analogy is,

As the greater side is to the lesser,

So is the Radius to the Tangent of the lesser angle.

Example. In the Triangle A B C, let there be known the side A B 230 yards, and the side A C 143 and three quarters very neer, and the included angle just 90 degrees; and let the angle B, being the lesser angle, be sought; the which to find,

Upon the lines of Numbers, Set 230, the greater side known on the first, to 143 & three quarters, the lesser side on the second; and then upon the lines of Tangents, against the Radius on the first, is the Tangent 32 degr. 0 min. on the second: So much is the quantity of the lesser angle, which is the angle at B; and the Complement of that to 90, is 58 degrees: So much is the quantity of the angle C, being the greater of the two angles sought.

If you would find the greater angle first, of the two unknown angles, then the Analogy is thus:

As

As the leſſer ſide; is to the greater,
So is the Radius, to the Tangent of the greater angle. Therefore,

Upon the lines of Numbers, Set the leſſer ſide known AC, 143 and three quarters on the firſt, to the greater ſide AB 230 on the ſecond and then on the lines of Tangents, againſt the Radius on the firſt, is the Tangent 58 degrees on the ſecond: So much is the quantity of the greater angle at C, & the Co-tangent thereof is 32 degrees: So much is the quantity of the leſſer angle. For it is to be noted, that alwayes the greater angle is oppoſite to the greater ſide, and the leſſer angle oppoſite to the leſſer ſide.

PROBLEM. V.

In any oblique angled Triangle, whether obtuſe or acute, having two ſides, and the angle included between them; to find the other angles.

IN the Triangle BCD, let the angle known be the obtuſe angle at C 122 degrees, & the two ſides including that angle, be C B the greater ſide, containing 271; & CD the leſſer ſide, containing 100, (which ſides may be reckoned poles, yards, feet, inches, or what other meaſure you pleaſe) and let the two angles at B and D be ſought.

In this caſe the Analogie will be thus:

As

As the sum of the two sides known,
Is to the difference betwixt the same sides;
So is the Tangent of the half sum of the two angles sought,
To the Tangent of the half of their difference.

Here the two sides including the known angle, are 100 and 271, which added together, their sum is 371, for the first number in the rule of Proportion. Next take the lesser side 100, from 271 the greater side, and the Remainder is 171, this is the difference between the sides, and is the second number in the rule: And then take the known angle 122 degrees from 180 degrees, or two right angles, and the Remainder is 58 degrees. So much is the quantity of both the other two angles at B and C, whereof the half is 29 degrees, this half sum is the third number in the rule of Proportion: These things had, then according to the Rule it is thus:

As 371 is to 171, So is the Tangent 29 deg. To the Tangent 14 deg. 20 min. Therefore,

Upon the lines of Numbers, Set 371 the sum of the two containing sides on the first, to 171 the difference of the same sides on the second; and then upon the lines of Tangents, against 29 degrees, the half sum of the two angles sought on the first, is the Tangent 14 deg.

deg. 20 min. on the ſecond. This 14 degr. 20 min. thus found, is the half of the difference of two angles ſought; therefore, To 29 degr. the half ſum of the angles ſought, add this 14 deg. 20 min. & the ſum is 43 degr. 20 min. So much is the quantity of the angle at D, the greater of the two angles ſought; and this 14 deg. 20 min. taken out of that 29 degr. 0 min. the Remainder is 14 deg. 40 min. So much is the angle B, the leſſer of the two angles ſought.

PROBLEM. VI.

In any right lined Triangle, whether right angled or oblique angled, any two ſides being known, with the angle included between them; to find the third ſide.

IN the oblique angled Triangle CBD, Suppoſe you have the two ſides given CD 100 yards, and C B 271 yards, and the angle C included betwixt them 122 degr. and you require to know the ſide DB oppoſite to the obtuſe angle C. Here firſt you muſt by the laſt Problem find out the two angles unknown, and then having the three angles and two ſides known, you may by the angles and one the ſides find the third ſide, according to the ſecond Problem: As ſuppoſe you would chooſe the ſide CD 100, and thereby work to find

find the side D B. Then the proportion will stand thus:

As 14 deg. 40 min. the sine of the angle opposite to the chosen side,
Is to 58 deg. the Complement of 122 deg. the angle C opposite to the side sought.
So is 100, the length of the chosen side C D,
To 335, the length of that side D B, which is required.

Therefore upon the lines of Sines, Set 14 deg. 40 min. the sine of the angle opposite to the chosen side on the first, to the sine 58 deg. the Complement of 122 deg. to 180; and then upon the lines of Numbers, against 100, the length of the side chosen on the first, is 335 on the second: So many yards is the length of the side D B, which was required.

Again, Suppose in the right angled Triangle B A C, right angled at A you have the two sides A B 230, and the side A C 143 and neer three quarters, and the included angle 90 degrees. Then to find the other two angles, work as in the last Problem thus: Add the two sides together, 230 and 143 and three quarters, and the sum is 373 and three quarters, for the first number. Then take the lesser side, 143 and three quarters, out of 320 the greater side, and the Remainder is 86, and one fourth for the second number, and the angle A is the third

number

number in the rule of Proportion. Therefore,

Set 373 and three fourths, the ſum of the ſides on the firſt, to 86 and one fourth, their difference on the ſecond; and then againſt the Tang. 45 deg. the half ſum of the two angles ſought on the firſt, is the Tang. 13 deg. on the ſecond, theſe deg. added to the 45 deg. and the ſum is 58 deg. for the greateſt of the two angles ſought: And taken from 45 deg. leaveth 32 deg. for the leſſer of them two angles.

The angles thus had, to find the third ſide C B. Set 32 deg. on the firſt, to 90 on the ſecond, and then againſt 143 and three fourths on the firſt, (the ſide choſen to work by) is 271 on the ſecond: So much is the length of the ſide C B, which is required.

Or elſe, making uſe of the ſide A B, Set the ſine 58 deg. to 90; and then on the lines of numbers, againſt 320 on the firſt, is 271 on the ſecond: The length of the ſide ſought, as before.

PROBLEM. VII.

In a right lined Triangle, the three ſides only being known; to find the Perpendicular; and thereby the three angles.

LEt the greateſt of the three ſides of your Triangle be taken for the Baſe, for ſo the Perpen-

Perpendicular will fall within the Triangle; then take the sum of the two sides by adding them together, and also their difference, by substracting the lesser from the greater: As in the Triangle G B D, make D B the Base, being the longer side 335 foot, and the other two sides be C D 100, and C B 271, these two sides added together make 371, and the lesser being substracted from the greater, their difference is 171. These had, the Proportion is thus:

As the Base D B 335,
is to the sum of the two sides 371;
So is the difference of the two sides 171,
to a fourth sum. Therefore,

Upon the lines of Numbers onely, Set 335, the length of the Base on the first. to 371 the sum of the sides on the second; and then against 171, the difference of the sides on the first, is 189,4 on the second; this 189,4 taken out from the Base 335,0, and the Remainder is 145,6 the half whereof is 72,8: So many foot measured in the line D B, from D towards B, (because the angle at D is the greatest of the two angles at the Base) will reach to E, the point where the Perpendicular E will cut the Base D B By which Perpendicular, the Triangle C D B, is divided into two right angled Triangles, D E C and C E B, which

which being done, all the other angles may be found by the third Problem of this Chapter: For here you have two sides D C 100, and D E 72,8, and the right angle D E C oppoſite to the ſide D C. Therefore by that third Problem, to find the angle E C D.

Set 100, the ſide oppoſite to the angle known on the firſt, to 72,8 the ſide oppoſite to the angle ſought on the ſecond; and then on the lines of ſines againſt 90 degr. the angle known is 46 degr. 40 minutes. So much is the quantity of the angle E C D, and its Complement to 90 is 43 deg. 20 min. for the quantity of the angle C D E. Thus have you the three angles of the right angled Triangle D E C; And for the length of the Perpendicular, it is thus attained unto by the firſt Problem. For,

Set 46 deg. 40 min. the quantity of the angle C, oppoſite to the known ſide E D on the firſt, to 43 deg. 20 min. the angle D oppoſite to the Perpendicular E C; and then on the lines of Numbers, againſt 72,8 the length of the ſide known on the firſt, is 68,5 and ſomething more: So much is the length of the Perpendicular E C, which was required.

In like manner, as the Angles and Perpendicular in this right angled Triangle are found, even ſo are found the Angles in that other right angled Triangle C E B on the other ſide of

of the Perpendicular; for you ſhall find the angle E B C 14 deg. 40 min. the angle B C E 75 deg. 20 min. And in concluſion, you ſhall find that the two angles at C, made by the Perpendicular, namely E C D and E C B will make juſt 122 degrees, which was the quantity of the obtuſe angle at C, before the Perpendicular was drawn.

PROBLEM. VIII.

In a right angled Triangle, the Angles and the Hypothenuſal being given, to find any one of the ſides including the right angle.

IN the right angled Triangle B A C, let the angles known be as afore, at C 58 deg. and at B 32 deg. and the angle at A a right angle, and the Hypothenuſal C B be 271 yards; and you would hereby find the ſides A C and A B, which for to do, the rule is thus by the lines on my Scale.

As the Radius, is to the angle oppoſite to the ſide ſought;

So is the Hypothenuſal or ſide oppoſite to the right angle, to that ſide ſought.

Therefore to find the ſide A C.

Set the Radius on the firſt, to 32 deg. on the ſecond, which is the angle oppoſite to the ſide ſought; and then, on the lines of Numbers, againſt

against 271 the side known on the first is 143 and three quarters very neer on the second: So many foot is the length of the side A C.

and for the side A B.

Set the Radius on the first to 58 deg. on the second, (which is the angle opposite to A B, the side sought;) and then on the lines of Numbers, against 271 the Hypothenusal on the first 230 on the second: So many foot is the length of the side A B.

Now for your further instruction; Let it be supposed, that A B is the altitude of some body, as a Tree, a Turret, a Steeple, or the like, which you would know, and can come no neerer to it than at C; therefore at C take the angle of altitude BCA 58 degrees, and then the angle at B the top of the altitude, made by the visual line C B, and the altitude A B will be 32 deg. being the Complement of the observed angle to 90 deg. for the altitude is supposed to stand perpendicular, and to make a right angle at the base A. Then from C, measure backwards in a right line 100 yards to D, and there observe the angle of altitude BD A, and find it 43 deg, 20 min, These two angles thus observed keep, and take the first observed angle at C 58 deg. out of 180 deg. and the Remainder is 122 deg. which is the quantity of the obtuse angle BCD made by the stationary

line C D, and the visual line C B. This angle of 122 deg. & the angle observed at D 43 deg. 20 min. add together and they make 165 deg. 20 min. which taken from 180 degr. the Remainder is 14 degr. 40 min. So much is the angle at B, the top made by the two visual lines C B and D B. Thus having attained the three angles of a Triangle C B D, and one side being the stationary distance, you may find the side or Hypothenusal C B, by the second Problem, and with the Hypothenusal, the altitude by this Problem.

CHAP.

CHAP. XI.

Of Trigonometria, ſhewing the uſe of the double Scales of Numbers; Sines and Tangents, in the reſolution of Triangles, either plain or ſpherical.

PROBLEM. I.

The two ſides of a rectangled Triangle being given to find the Baſe, which is the ſide oppoſite to the right angle.

IN the Triangle A B C of the annexed Diagram, Let the ſide AC be 27 deg. 45 min. and the ſide C B 11 deg. 30 min. be given, and the baſe A B required,

For reſolution of this *quære*, ſay thus:

As the Radius is to the Co-ſine of one of the given ſides; So is the Co-ſine of the other given ſide to the Co-ſine of the baſe. Therefore

Set the Radius on the firſt, to 62 deg. 6 min. the Co-ſine of the one ſide given, *viz.* of A C 27 deg. 54 min. on the ſecond; and then againſt the Co-ſine of B C, 11 degr. 30 min. which is 70 deg. 30 min. on the firſt, is 60 deg

the Co-sin: of the side or base required: So then the base A B is 30 degrees.

PROBLEM. II.

The two sides being given, to find either of the oblique angles.

IN the Triangle A B C aforementioned; Let A C be given 27 deg. 54 min, and B C 11 deg. 30 min. and let the angle A, next the side A C, be sought. Say,

As the sine of the side next the angle sought, is to the Radius; So is the Tangent of the side opposite to the angle sought, to the Tangent of the same angle. Therefore.

Set 27 deg. 54 min. the side adjacent to the angle sought, to the Radius on the second; and then against the Tangent of 11 deg. 30 min. the side opposite to the angle sought on the first, is the Tangent 23 deg. 30 min. on the second: So much is the angle at A that was required.

If the angle sought for do appear to be above 45 deg. as doth the angle B, and the sides less than 45 deg. then the best way to find B, is by the next Problem to find the base, and then having the base to find the angle B.

But if the side opposite to the angle sought be above 45 degrees, as suppose the sides A C were

were 61 deg, 53 min. and C B 54 deg, 28 min. and the angle A ſought for. Then work thus,

Set the Radius on the firſt, to the ſine of the ſide adjacent to the angle ſought, *viz.* to the ſine of A C 61 degr. 53 min. on the ſecond; and then againſt the tangent 54 degr. 28 min. the ſide oppoſite to the angle ſought on that firſt, is 57 degr. 47 min. the Tangent of the angle A ſough for. Here note, that in examples of this kind the angle found is greater than 45 degrees.

PROBLEM. III.

One ſide, and the oblique angle next unto it being given; to find the Baſe.

LEt the ſide A C 27 degr. 54 min. and the angle A 23 deg. 30 min. be given, and the Baſe A B ſought.

As the Co-ſine of the angle given,
is to the Radius;
So is the tangent of the ſide given,
to the tangent of the baſe. Therefore,

Set 66 deg. 30 min. the Co-ſine of the angle given, to the Radius, and then againſt the tangent 27 deg. 54 min. on the firſt, is the tangent 30 deg. on the ſecond, the baſe ſought.

If the ſide given be above 45 degrees, as were the ſide A C, 61 deg. 53 min. and the angle A

57 deg. 47 min. then to find the baſe; Set the Radius to 32 degr. 13 min. the Co-ſine of the angle given, and then againſt the tangent of the ſide 61 degr. 53 min. is the tangent 74 degr. 6 min. for the baſe A B.

PROBLEM. IV.

The Baſe, and one of the oblique angles being given; to find the other oblique angle.

IN the Triangle aforeſaid; Let there be given the Baſe 30 degrees, and the oblique angle A 23 deg. 30 min. and the angle B required. Say,

As the Radius, is to the Co-ſine of the Baſe;
So is the Tangent of the angle given, to the Co-tangent of the angle required.

Therefore,

Set the Radius on the firſt, to 60 degr. the Co-ſine of the Baſe; and then againſt 23 deg. 30 min. the tangent of the angle given, is the tangent 20 deg. 38 min. which is the Co-tangent of the angle B. Wherefore the ſaid angle is 69 deg. 22 min.

If the angle given be above 45 degrees; As if the angle given be the angle B, and the leſſer angle A ſought, then, Set the Co-ſine of A B 60 degrees on the ſecond to the Radius; and then againſt the tangent of the given angle 69 degrees 22 minutes on that firſt, is 23 de-

23 degrees 30 minutes, the Tangent of the Angle A.

PROBLEM. V.

The Base, and one of the oblique angles given: to find the side next the same angle.

LEt the Base A B 30 degr. and the angle A 23 deg. 30 min. be given, and let the side A C adjacent to the angle A be required. Say,

As the Radius, to the Co-sine of the angle given;

So is the tangent of the base, to the tangent of the side sought. Therefore,

Set the Radius on the first, to 66 degr. 30 min. the Co-sine of the angle given on the second; and then against the tangent of the base 30 degrees, is the tangent of the side sought, 27 deg. 54 min.

If the base be above 45 degrees: as, Let the base A B be 74 deg. 6 min. and the angle A 57 deg. 47 min. and then to find the base.

Set 33 degr. 13 min. the Co-sine of the angle given on the first, to the Radius on the second; and then against the tangent of the base 74 deg. 7 min. on the first, is 61 degr. 53 min. the side A C sought for.

PROBLEM. VI.

The Baſe, and one of the oblique angles given: to find the ſide oppoſite to the angle given.

LEt the Baſe A B 30 degrees, and the angle A 23 degrees 30 minutes be given, and let the ſide C B oppoſite to the ſame angle A be ſought.

As the Radius, to the Sine of the Baſe;
So is the Sine of the angle given, to the Sine of the ſide ſought. Therefore,

Set the Radius on the firſt, to 30 degrees, the Sine of the Baſe on the ſecond; and then againſt 23 deg. 30 min. on the firſt is 11 degr. 30 min. on the ſecond, the ſide C B, which was ſought for.

PROBLEM. VII.

One ſide, and the oblique angle next it being given; to find the other ſide.

LEt the ſide A C, 27 degr. 54 min. and the angle A 23 deg. 30 min. be given, and the ſide B C required. Say,

As the Radius, to the Sine of the ſide known;
So is the tangent of the angle known, to the tangent of the ſide required. Therefore:

Set

Set the Radius on the first, to 27 degr. 54 minutes, the sine of the side known; and then against the tangent of the angle A, 23 degrees 30 min. on the first, is the Tangent 11 degr. 30 minutes for the side C B, which was required.

PROBLEM. VIII.

One side, and the oblique angle next it being known; to find the other oblique angle.

LEt the side A C, 27 degr. 54 min. and the angle A 23 deg. 30 min. be given, and the angle B sought. Say,

As the Radius, to the Co-sine of the side given;

So is the Sine of the angle given, to the Co-sine of the angle sought. Therefore,

Set the Radius on the first, to 62 deg. 6 min. the Co-sine of 27 degr. 54 min. the side given; and then against the Sine of the angle given, 23 deg. 30 min. is the Sine 20 deg. 38 min. the Complement of 69 degr. 22 min. the angle B, which was required.

PRO-

PROBLEM. IX.

One side, and the angle opposite to it being known; to find the Base.

LEt the side B C 11 deg. 30 min. and the angle A 23 deg. 30 min. be given, and let the base A B be sought for. Say,

As the sine of the angle given, to the sine of the side given;

So is the Radius, to the sine of the base.

Therefore,

Set 23 deg. 30 min. the sine of the angle given on the first, to 11 deg. 30 min. the sine of the side given; and then against the Radius on the first, is the sine 30 deg. on the second. Therefore 30 deg. is the base sought for.

PROBLEM. X.

One side, and the angle opposite to it being given; to find the other side.

LEt the side B C 11 deg. 30 min. and the angle A 23 deg. 30 min. be given, and the side A C sought for. Say,

As the Tangent of the angle given, is to the Tangent of the side given;

So is the Radius, to the sine of the other side. Therefore,

Set

Set the Tangent of the angle A, 23 degr. 30 min. on the first, to the Tangent of 11 deg 30 min. on the second; and then against the Radius on the first, is 27 deg. 54 min. The sine of the side A C, sought for.

Sometime it so falleth out in this Problem, and some others, by reason of a great angle or side, that the resolution cannot be readily done by the Analogy set down; yet you shall see ready wayes upon the lines to perform the same, or by other Problems to gain the thing sought.

PROBLEM. XI.

One side, and the angle opposite to it being known; to find the other angle.

LEt the side C B 11 deg. 30 min. and the angle A 23 deg. 30 min. be given, and the angle B sought. Say,

As the Co-sine of the side given, to the Co-sine of the angle given;

So is the Radius, to the sine of the angle required. Therefore,

Set 78 deg. 30 min. the Co-sine of the side C B given on the first, to 66 deg. 30 min. the Co-sine of A the angle given; and then against the Radius on the first, is 69 deg. 22 min. on the second. The sine of the angle sought.

PRO-

PROBLEM. XII.

The Base, and one side known; to find the oblique angle adjoyning to the same side.

LEt the side A C, 27 degr. 54 min. and the Base A B 30 degrees, be given, and the angle A adjoyning to the side given, sought for.

Say,

As the tangent of the Base, to the tangent of the side given;

So is the Radius, to the Co-sine of the angle required. Therefore,

Set the tangent of the Base 30 degr. on the first, to 27 degr. 54 min. the tangent of A C, the side given on the second; and then against the Radius on the first is 66 degr. 30 min. on the second, whose Co-sine is 23 degr. 30 min. The sine of the angle A that was sought.

When the Base and side be above 45 degr. as, Suppose the Base AB to be 74 deg. 6 min. and the side A C 61 deg. 53 min. then set the tangent of that side next the angle sought, *viz*, 61 deg. 53 min. on the first, to the tangent of the Base 74 deg. 6 min. on the second; and then against the Radius on the first, is 32 degr. 13 min. the Co-sine of the angle A. After this manner, by altering the placing of the terms given, one way or other, any *quære* may be resolved.

PRO-

PROBLEM. XIII.

The Base, and one side being given; to find the angle opposite to the same side.

LEt the side A C, 27 degr. 54 min. and the Base A B 30 deg. be given, and the angle B required. Say,

As the sine of the Base, to the Radius;
So is the sine of the side given, to the sine of the angle required.

Set 30 deg. the sine of the Base on the first, to the Radius on the second; and then against 27 deg. 54 min. the sine of A C the side given on the first, is 69 deg. 22 min. The sine of the angle B, which was required.

PROBLEM. XIV.

The Base, and one side being given; to find the other side.

LEt the side A C 27 deg. 54 min. and the Base A B 30 degr. be given, and the side C B sought for. Say,

As the Co-sine of the side given, to the Radius; So is the Co-sine of the Base, to the Co-sine of the side sought. Therefore,

Set 62 deg. 6 min. the Co-sine of the side given, to the Radius; and then against 60 degr. the

the Co-sine of the Base, is 78 deg. 30 min. the Co-sine of the side B C, 11 degr. 30 min. that was required.

PROBLEM. XV.

The two oblique Angles being given, to find the Base.

LEt the angle A be 23 deg. 30 min. and the angle B 69 deg. 22 min. be given, and let the Base A B be sought.

As the tangent of one of the angles, is to the Co-tangent of the other angle;

So is the Radius, to the Co-sine of the Base. Therefore,

Set the tangent of the one angle, as of that at A 23 degr. 30 min. on the first, to the Co-tangent of the other angle, *viz.* to 20 degr. 38 min. on the second; and then against the Radius on the first, is the sine 60 degrees on the second. Which is the Co-sine of 30 degrees, the Base A B, which was required.

PROBLEM. XVI.

The two oblique angles being given; to find either of the sides.

LEt the angle A be 23 degr. 30 min. and the angle B 69 deg. 22 min. and let the side A C be sought. Say, As

As the ſine of one of the angles, is to the Co-ſine of the other angle;
So is the Radius, to the Co-ſine of the ſide oppoſite to that angle, whoſe Co-ſine was taken. Therefore,

Set the ſine of the angle A 23 deg. 30 min. on the firſt, to 20 deg. 38 min. the Co-ſine of the other angle B 69 deg. 22 min. And then againſt the Radius, is 62 degr. 6 min. which is the Co-ſine of 27 deg. 54 min. the ſine of the ſide A C ſought. Having ſhewed the uſe of the double lines, through all the varieties of right angled Spherical Triangles, I come to the Oblique.

In Oblique angled ſpherical Triangles.

PROBLEM. XVII.

Two angles, and a ſide oppoſite to one of them being given; to find the ſide oppoſite to the other.

LEt the Triangle propoſed be A B E, wherein let be given the angle E. 38 deg. 15 min. and the ſide B A 30 degrees, and the angle A 23 deg. 30 minutes, and let the ſide B E be ſought. Say,

As

As the Sine of the angle oppoſite to the ſide known, is to the Sine of the ſame ſide;
So is the Sine of the angle oppoſite to the ſide ſought, to the Sine of that ſame ſide.
Therefore,

Set 38 deg. 15 min. the ſine of the angle E, to the Sine of the ſide given 30 deg. (*viz.* A B) And then againſt 23 degr. 30 min. the Sine of the other angle A on the firſt, is 18 degr. 47 min. The Sine of B E, the ſide ſought.

PROBLEM. XVIII.

Two ſides, and an angle oppoſite to one of them being known; to find the angle oppoſite to the other of them.

IN the Triangle A B E, let the ſide A B be 30 deg. the angle E 38 degr. 15 min. and the ſide B E 18 deg. 47 min. and let the angle A, which is the angle oppoſite to the ſide B E, be ſought. Say,

As the Sine of the ſide oppoſite to the angle given, is to the Sine of the ſame angle;
So is the Sine of the ſide oppoſite to the angle ſought, to the Sine of that ſame angle.
Therefore,

Set 30 degrees, the ſide A B on the firſt, to 38 deg. 15 min. the Sine of its oppoſite angle on the ſecond; and then againſt 18 deg. 47 min. the

the ſine of B E the other ſide, is 23 degr. 30 min. the ſine of A its oppoſite angle, which is the thing that was to be ſought.

PROBLEM. XIX.

Two ſides, and the angle included between them, being known; to find the other ſide oppoſite to that angle.

IN the Triangle A B E, let the ſides A B 30 deg. and A E 42 deg. 51 min. with the angle A included between them, be given, and the ſide B E required.

Here firſt a Perpendicular muſt be ſuppoſed to be let fall from the unknown angle B, to the ſide A E oppoſite to that angle, & now to find on what part of the ſide A E it will fall. Say,

As the Radius, to the Co-ſine of the included angle A;

So is the Tangent of A B, to the Tangent of A C: Therefore,

Set the Radius on the firſt, to 66 deg. 30 min. the Co-ſine of the included angle A; and then againſt the Tangent of A B 30 degrees the leſſer ſide, is 27 degrees 54 minutes, the Tangent of the diſtance from A to C, on the ſide A E; therefore C is the point whereon the Perpendicular will fall. This diſtance A C 27 deg. 47 min. deduct out of the whole ſide A E

42 deg. 51 min. And the Remainder is 14 deg. 57 min. Then say,

As the Co-sine of A C, the distance found,
Is to the Co-sine of C E, the Remainder;
So is the Co-sine of A B, the lesser side, to
the Co-sine of B E, the side required.

Therefore,

Set 62 deg. 6 min. the Co-sine of A C, the distance found, 75 degr. 3 min. the Co-sine of C E, the Remainder; and then against 60 degrees, the Co-sine of the side A B. is 71 deg. 13 min. the Co sine of B E, 18 deg. 47 min. the side required.

It is to be observed, that in oblique angled Triangles, when the terms propounded are two sides and one angle, or two angles and one side, and yet not resolveable by the two last Problems before this: That then a Perpendicular is to be let fall, (or supposed to be let fall) from one of the unknown angles, to the side opposite thereto; and so of the oblique angled Triangle given, to make two right angled Triangles. Which being done, all the parts of such a Spherical Triangle, may be found out by the former Problems of right angled Triangles. This perpendicular will sometime fall within the Triangle, and that is, when the angles at the ends of the side whereon the Perpendicular fals, are both of one kind, that is to say,

ſay, both acute, or both obtuſe; as in the Triangle A B E. And ſometime this perpendicular fals without the Triangle, and that is, when the angles at the ends of the ſide whereon it fals, are of differing kinds; that is, one acute, & the other obtuſe, as in the Triangle A D B, where the Perpendicular B C fals on the ſide A D, it being prolonged, as it muſt alwayes be in thoſe caſes.

PROBLEM. XX.

Two ſides with the angle included between them, being given; to find either of the other angles.

LEt the ſides A B 30 degr. and A E 42 degr. 51 min. with the angle A 23 degr. 30 min. be given, and the angle E ſought.

As in the laſt Problem, ſo here a Perpendicular muſt be let fall on the given ſide A E, from its oppoſite angle B, and ſo of the oblique angled Triangle, make two rectangled Triangles. This Perpendicular, as afore was ſhewed, is thus found: Set the Radius to 66 degr. 30 min. the Co-ſine of the included angle; and then againſt the Tangent of 30 deg. the further ſide, is the Tangent 27 degr. 54 min. So much is the part of the ſide A E, betwixt A and the point C, where the Perpendicular falleth. Now if 27 degr. 54 min. be taken from

42 deg. 51 min. the Remain is 14 deg, 57 min. for the side of the rectangled Triangle B C E. Now to find the angle E, the Analogie is thus.

As the sine of the side C E, is to the sine of the side A C; So is the Tangent of the angle included, to the Tangent of the angle sought.

And therefore,

Set the sine of C E, 14 deg. 57 min. on the first, to the sine of A C, 27 degr. 54 min. the part found; and then against the Tangent of A, 23 deg. 30 min. is the tangent 38 degr. 15 min. the Angle E that was sought.

Otherwise, having let fall the Perpendicular, and having found C E, 14 deg. 57 min. together with the Base 18 degr. 47 min. then to find E, work as by the 12 Problem of rectangled Spherical Triangles, in this manner.

Set the Tangent of the Base, 18 degr. 47 min. to the Tangent of that part of the side C E; 14 degr. 57 min. And then against the Radius on the first, is 38 degr. 15 min. the sine of the angle E, as before. In this manner may any of the other terms be also found out, by one or other of those Problems.

PRO-

PROBLEM. XXI.

Two ſides, and one angle next to the ſide ſought being given; to find the ſame ſide.

LEt the ſides A B 30 degr. and B E 18 degr. 57 min. and the angle A 23 deg. 30 min. be given and the ſide A E required. Here firſt let fall the perpendicular B C, and ſay,

As 60 deg. the Co-ſine of A B, is to 71 deg. 13 min. the Co-ſine of B E, 18 degr. 47 min.

So is the Co-ſine of A C 27 degr. 54 min. *viz.* 62 deg. 6 min. to 75 degr. 3 min. the Co-ſine of C E. Therefore,

Set 60 deg. the Co-ſine of A B, to 71 degr. 13 min. the Co-ſine of B E; and then againſt 62 deg. 6 min. the Co-ſine of A C, is 14 degr. 3 min. the Co-ſine of C E. wherefore C E is 14 degr. 57 min. which added to A C 27 degr. 54 min. makes 42 degr. 51 min. for the ſide A E, which was ſought.

PROBLEM. XXII.

Two sides, and an angle adjacent to one of them being given; to find the angle included between the same sides.

LEt the sides given be A B, 30 degrees, and B E 18 degr. 47 min. with the angle A 23 deg. 30 min. and let the obtuse angle B included betwixt the two sides, B A, and B E, be required: To resolve this demand, Say,

1 As the Radius, to the Co-sine of A B; So is the Tangent of the angle A, to the Tangent of a B c.

2 As the tangent of B E, to the Tangent of A B; So is the Co-sine of a B c, to the Co-sine of c B e. Therefore,

1 Set the Radius, to 66 degrees, the Co-sine of A B, and then against the Tangent of A 23 degr. 30 min. is the Tangent 69 degr. 22 min. the angle a B c, made by letting fall the Perpendicular, and is part of the angle a B e sought. Now to find the Remainder.

2 Set 18 degr. 47 min. the Tangent of B E on the first, to the Tangent of A B 30 degrees, and then against the Co-sine of a B c, which is 20 deg. 38 min. is 36 deg. 46 min. whose Compliment is 48 degr. 14 min. is the angle c B e, which

which added to 69 degr. 22 min. makes 122 deg. 36 min. the angle a Be, which is the thing required.

PROBLEM. XXIII.

Two angles, with the side lying betwixt them being known; to find either of the other sides.

LEt be given the angles A 23 degr. 30 min. and B 122 degr. 36 min. and the side A B 30 degrees, & let the side B E be required. In which case having let fall the perpendicular B C, and found the angle c B e. Say,

As the Co-sine of c C e, is to the Co sine of a B c;

So is the Tangent of A B, To the Tangent of B E. Therefore,

Set 36 degr. 46 min. the Co-sine of the angle c B e on the first, to the Co-sine of the angle a B c; and then against 30 degrees, the tangent of the side given, is the tangent 18 deg. 47 min. the side B E, which was required.

PROBLEM. XXIV.

Two angles, with the side lying betwixt them being given, to find the third angle.

LEt the angle A 23 deg. 30 min. and the angle B 122 degr. 36 min. with the side A B

30 degrees be given, and the third angle at E, required.

Having let fall the Perpendicular, and found the angles a B c, and c B e. Then say,

As the Sine of a B c, is to the Sine of c B e;
So is the Co-sine of A, the angle given, to the Co-sine of E, the angle sought.

Therefore,

Set 69 deg. 22 min. the Sine of a B c on the first, to 53 degr. 14 min. the Sine c B e on the second; and then against the Co-sine of A 66 deg. 30 min. on the first, is 51 degr. 45 min. the Co-sine of the angle E. Wherefore E is 38 deg. 15 min.

PROBLEM. XXV.

Two angles, and a side opposite to one of them being given; to find the side adjacent to both the angles.

LEt the angles A 23 degr. 30 min. and E 38 15 min. with the side B A 30 degrees, being opposite to the angle E be given, and the side A E required.

Having let fall the Perpendicular, and together with it found A C, a part of A E.

Say then,

As the tangent of E, is to the tangent of A:
So is the sine of A C, to the sine of C E.

There-

Therefore,

Set 38 deg. 15 min. the tangent of E on the firſt, to 23 deg. 30 min. the Tangent of A on the ſecond; and then againſt 27 deg. 54 min. the ſine of the ſide of A C on the firſt, is 14 deg. 57 min. on the ſecond, which is the ſine of C E. This 14 deg. 57 min. added to 27 deg. 54 min. the other part A C afore found, makes 42 deg. 51 min. for the whole ſide A E, which was ſought.

PROBLEM. XXVI.

Two angles, and a ſide oppoſite to one of them being known; to find the third angle.

LEt the angles given be A 23 deg 30 min. and E 38 deg 15 min. and let the ſide A B, being oppoſite to the angle E, be 30 degr. and let the third angle a B e be required.

As in the former Problems, ſo alſo in this; Let fall the Perpendicular B C, and by it gain the angle a B c, which being had, to gain the Remainder of the angle a B e. Say,

As the Co-ſine of the angle A, is to the Co-ſine of the angle E;

So is the ſine of a B c, to the ſine of c B e.

Therefore,

Set 66 deg. 30 min, the Co-ſine of the angle A on the firſt, to 51 deg. 45 min. the Co-

ſine

ſine of the angle E on theſecond; and then againſt 69 degr. 22 min. the ſine of a B c on the firſt, is 53 degr. 14 min. the ſine of c B e. Theſe two angles added together, make 122 degr. 36 min. the angle A B E, which was required.

PROBLEM. XXVII.

The three ſides being given, to find any one of the angles.

LEt the three ſides be A B 30 deg. A E 42 deg. 51 min. and B E 18 deg. 47 min. and let the angle B be ſought.

To reſolve this Problem: Firſt, Add all the three ſides together into one ſum, of which ſum take the half, and then from that half take the ſide oppoſite to the angle ſought, and reſerve the difference. As for Example.

The three ſides given, are	A B 30 d. 00 m.	
	A E 42 d. 51 m.	
	B E 18 d. 47 m.	
The ſum of the three ſides		91 d. 38 m.
The half of that ſum		45 d. 49 m.
The ſide A E, oppoſite to the required angle B, ſubſtracted		42 d. 51 m.
And the Differ. to be reſerved is		2 d. 58 m.

This

This done, to proceed to find the angle sought. Say,

1 As the Radius, is to the Sine of one of the sides including the angle sought; So is the Sine of the other side, including the same angle, to a fourth Sine.

2 As that fourth Sine, is to the Sine of the half sum; So is the Sine of the reserved difference, to a seventh Sine.

Therefore,

1 Set the Radius on the first, to 30 deg. the Sine of one of the sides given, including the angle sought; and then against 18 deg. 47 min. the Sine of the other including side, is 9 degr. 16 min. for a fourth Sine.

2 Set this fourth Sine 9 deg. 17 min. on the first, to 45 deg. 49 min. the Sine of the half sum on the second; and then against 2 degr. 58 min. the Sine of the reserved difference, is 13 deg. 20 min. for the seventh Sine.

This being done (by the help of a pair of Compasses, or otherwise) divide the distance betwixt this point of 13 deg. 20 min. and the Radius into two equal parts, and the middle point is at 28 deg. 42 min. whose Complement 61 degr. 18 min. doubled, makes 122 degr. 36 min. the angle a B e, which was sought.

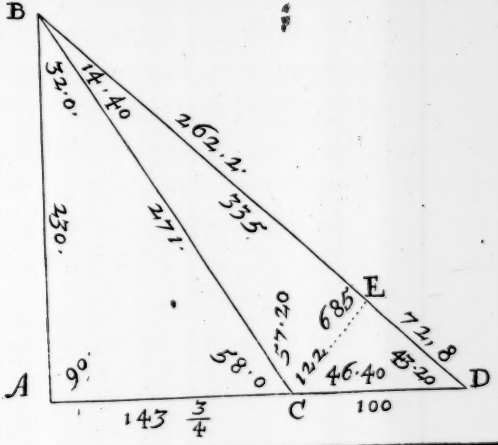
PRO-

PROBLEM. XXVIII.

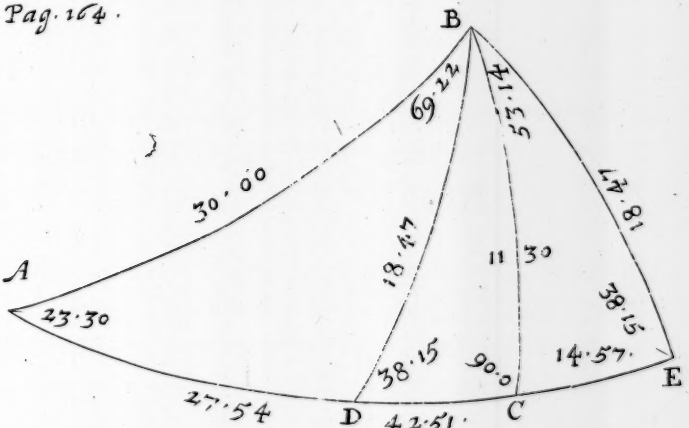
The three angles being onely known, to find any of the sides.

TO resolve this Problem, the angles are to be turned into sides, and the sides into angles, (otherwise it is unresolveable) and it is thus done: Instead of the greatest angle, take its Complement to 180 degrees, and then the angles convert themselves into sides, and the sides into angles, and then the resolution is just the same as in the last Problem.

CHAP.


B
32.0.
14.40
262.2.
230.
271.
335
E
685
57.20
72,8
122
58.0
46.40
43.20
A
90.
D
C
143 3/4
100

Pag. 164.


B
69.22
53.14
30.00
18.47
18.47
11 30
A
23.30
38.15
38.15
90.0
14.57.
E
27.54
D
42.51.
C

CHAP. XII.

The Use of the Instrument in Navigation.

THis Instrument, with these Double Scales inscribed thereon, is of most excellent use in Navigation, as I shall shew in part, and leave the rest to the Ingenious to find out of themselves. And first, by the Meridian Line, and Line of equal parts joyned together upon the Instrument, you may do all things that may be done by the Table of Meridional Degrees, set forth by Mr. *Wright*, Mr. *Gunter*, Mr. *Wingate*, and others treating of Navigation.

PROBLEM. I.

Two places being propounded, the one under the Equinoctial, and the other without; to find their Meridional Difference.

LOok the Latitude of that place situate without the Equinoctial, upon the Meridian line, and right against it, on the Line of equal parts, is the Meridional Difference of those two places.

Example.

Example. Let the entrance of the River of the Amazons, under the Equinoctial, be one place propounded, and the Lizard in the Latitude of 50 degrees be the other place, between which the Meridional Difference is desired.

Look 50 degrees, the Latitude of the Lizard on the Meridian Line, and right against it on the Line of equal parts, is 57 degrees, 90 centesimal minutes, which is 57 degrees, and 9 tenth parts of a degree, or 57 degrees, 54 sexaginary minutes. So much is the Meridional Difference of those two places.

PROBLEM. II.

Two places having both Northerly, or both Southerly Latitude; to find their Meridional Difference.

Substract the degrees and minutes which you find on the Line of equal parts against the lesser Latitude, from the degrees and minutes found on the same Line of equal parts against the greater Latitude, and the Remainder is the Meridional Difference of those two places.

Example. Let St. *Christophers* and the *Lizard* be two places, between which you would find the Meridional Difference; the Latitude of St.

St. *Chriſtophers* is known to be 15 degrees 30 minutes North, to which anſwereth on the Line of equal parts 15 deg. 69 centeſimal minutes: the Latitude of the *Lizard* is alſo known to be 50 degrees North. To which on the Line of equal parts anſwereth 57 degr. 90 centeſms. Now take 15 degr. 69 cent. the leſſer number of degrees found on the Line of equal parts, out of 57 deg. 90 cent. the greater number of degrees found on the Line of equall parts, and the Remainder is 42 degr. 21 cent. or 42 deg. 12 min. of the ſexaginary diviſion. So much is the Meridional Difference deſired.

PROBLEM. III.

Two places being ſituate, the one Southerly, and the other Northerly; to find the Meridional Difference.

TAke the degrees and parts found on the Line of equal parts, againſt the two Latitudes propoſed, ſought in the Meridian Line, and add them both together, and the ſum of that addition is the Meridional Difference.

Example. Let the two places propoſed be the *Cape of Good Hope*, in the Latitude of 36 deg. 30 min. South, and *Japan* in the *Eaſt Indies*, whoſe Latitude is 30 degrees North. Now on the Meridian Line, look 36 degr. 30. min. and againſt

against it on the Line of equal parts, is 39 deg. 15 min. and against the 30 degrees is 31 deg. 28 min. These two sums 39,15, and 31, 28, being added together, make 70 deg. 43 min. So much is the Meridional Difference required.

PROBLEM. IV.

The Latitude of two places, and their Difference of Longitude being known; to find the Rumb leading from the one to the other.

LEt the two places proposed be the *Lizard* and St. *Christophers*; the Latitude of the *Lizard* 50 degrees, and of St. *Christophers* 15 deg. 30 min. and their Difference of Longitude 68 deg. 30 min. And let the Rumb passing from the *Lizard* to St. *Christophers* be required.

First, by the second Problem, seek the Meridional Difference between the two places, which you find to be 42 deg. 12 min. by that second Problem. Then,

Upon the Line of Numbers, Set 68 degrees 30 min. the Difference of Longitude on the first, to 42 deg. 12 min. the Meridional Difference on the second; and then upon the Lines of Tangents against the Radius on the first, is the Tangent 58 deg. 21 min. on the second. So much lieth the Rumb from the Meridian, which is on the fifth Rumb from the Meridian West-

Westwards, and two degrees 6 minutes, over and above that fifth Rumb.

And if you be to sail from the *Lizard* to the *Bermudas Ilands*, in the Latitude of 32 degr. 25 min. whose Difference of Longitude is known to be Westwards 70 degrees; and you would know on what point of the Compasse you must steer your course thither.

Here first by the second Problem, seek the Meridional Difference, and find it 23 deg. 36 min. And then,

Set 70, the Difference of Longitude on the first, to 23 deg. 36 min. the Meridional Difference on the second; and then against the Radius on the first, is the Tangent 71 deg. 21 min. on the second; that is, on the point 71 deg. 21 min. from the Meridian, or South point, which is on the sixth Rumb, and 3 deg. 51 min. over. And because the *Bermudas* lye Westwards from the Meridian of the *Lizard*; therefore the Rumb is the West Southwest point, and 3 deg. 51 min. over.

Here is to be noted, that every Rumb from the Meridian containeth 11 deg. 15 min. And therefore the first Rumb makes an angle with the Meridian of 11 degr. 15 min. the second Rumb an angle of 22 deg. 30 min. and so of the rest, as in the little Table following appeareth, wherein you see that the sixth Rumb

makes an angle of 67 degr. 30 min. which taken from 71 deg. 21 min. in this last Examp'e found, there remained 3 deg. 21 min. over the sixth Rumb.

Rumbs	1	11 deg. 15 min.
	2	22 deg. 30 min.
	3	33 deg. 45 min.
	4	45 deg. 00 min.
	5	56 deg. 15 min.
	6	67 deg. 30 min.
	7	78 deg. 45 min.
	8	90 deg. 00 min.

PROBLEM. V.

The Latitudes of two places being given with the Rumb; to find the distance upon the Rumb.

LEt the place from whence you sail be in the Latitude of 50 degrees, and the Latitude of a place to which you are come, be 52 deg. 30 min. So that the Difference of Latitude is 2 deg. 30 min. find also you, and that you have sailed on the first Rumb, from the Meridian Northerly, that is, have made an angle with the Meridian of 56 deg. 15 min. The Complement of the fifth Rumb to eight is 3, which is 33 deg. 45 min. and you would know your distance sailed upon that Rumb.

Set

Set 33 degr. 45 min. the Co-ſine of the Rumb on the firſt, to the Radius on the ſecond; and then on the Line of Numbers, againſt 2,50 the Difference of Latitude on the firſt, is 4,50 on the ſecond, that is to ſay, 4 degrees 50 centeſmes, or 4 deg. 30 min. So much is the diſtance ſailed upon that courſe, in degrees and minutes.

Again, Let the *Lizard*, lying in 50 degrees of North Latitude, be the place from whence you are to go; and let the other place that you are to go unto be *St. Chriſtophers*, in the Latitude of 15 deg. 30 min. North. And the Rumb leading from one to the other, bearing from the Meridian of the *Lizard* 58 degr. 21 min. which is ſomething more than the fifth Rumb. Now by theſe things known, you would know the diſtance upon the Rumb between thoſe two places.

Here you muſt firſt of all ſubſtract 15 degr. 30 min. the leſſer Latitude out of 50 degrees, the greater Latitude, and the Remainder 34 deg. 30 min. is the true Difference of Latitude; and then, Set 31 degr. 39 min. the Co-ſine of the Rumb on the firſt, to the Radius on the ſecond; and then on the Line of Numbers, againſt 34,30 repreſenting 34 deg. 30 min. the Difference of Latitude on that firſt, is 65,46 on the ſecond, that is 65 deg. 46 min. So much

in degrees and minutes, is the diſtance upon the Rumb between the *Lizard* and St. *Chriſtophers*.

PROBLEM. VI.

The Latitudes of two places, and their diſtance being known; to find the Rumb leading from one to another.

LEt the two places propounded be thoſe mentioned in the laſt Problem, whoſe Latitudes were 50 degrees, and 52 deg. 30 min. and their diſtance known 4 deg. 30 min. & the Rumb you know not, but deſire to know it.

Upon the Line of Numbers, Set 4,30 repreſenting 4 deg. 30 minutes, the diſtance known, on the firſt, to 2,30 repreſenting 2 degrees 30 minutes, the Difference of Latitude on the ſecond; and then upon the Lines of Sines, againſt the Radius on the firſt, is the Sine 33 degr. 45 min. on the ſecond, whoſe Co-ſine is 56 deg. 15 min. So much is the diſtance that the courſe lieth from the Meridian, which is upon the fifth Rumb.

Or let the *Lizard*, in the Latitude of 50 deg. and St. *Chriſtophers* in the Latitude 55 deg. 30 min. be the two places propoſed, whoſe Difference of Latitude is 34 deg. 46 min. and their diſtance known 65 deg. 46 min. and the Rumb that the courſe lieth upon, is deſired.

Upon

Upon the Line of Numbers, 65,46 the diſtance known on the firſt, to 34,46 the Difference of Latitude on the ſecond; and then on the Lines of Sines, againſt the Radius on the firſt, is 58 degr. 21 min. on the ſecond. So much is the diſtance of the Rumb from the Meridian of the *Lizard*, on which the Courſe lieth.

PROBLEM. VII.

The Latitude of the place from whence you go, the Rumb you go upon, and the diſtance gone, being given; to find the Difference of Latitude, and thereby the Latitude of the place you are in.

LEt the place you go from, be in the Latitude of 50 degrees, the Rumb you have gone upon, the fifth from the Meridian, and the diſtance gone, 4 degr. 30 min. And by theſe you deſire to know the Difference of Latitude, with the latitude of the place you are in.

Set the Radius on the firſt, to 33 degr. 45 min. the Co-ſine of the Rumb on the ſecond; and then upon the Lines of Numbers, againſt 4, 30 repreſenting 4 deg. 30 min. the diſtance gone on the firſt, is 2,30 on the ſecond, that is 2 deg. 30 min. So much is the Difference of Latitude. This 2 deg. 30 min. added to the Latitude of the place you came from, (becauſe

the Course was Northerly) makes 52 deg. 30 min. for the Latitude of the place you are in.

Example. Suppose you were at *St. Christophers*, in the Latitude of 15 degr. 30 min. and from thence had sailed Northwards neer upon the fifth Rumb from the Meridian; or on the true point of 58 deg. 21 min. from the Meridian, and at length came to a place, where you found that you had sailed 65 deg. 46 min. from *St. Christophers*, and now do desire to know in what Latitude you are.

Set the Radius on the first, to 31 degr. 39 min. the Co-sine of the Rumb on the second; and then upon the Line of Numbers, against 65,46 representing 65 deg. 46 min. the distance gone on the first, is 34, 30 on the second, signifying 34 deg. 30 min. So much doth the Latitude you are in, differ from that you came from, and because the Course was Northerly, the Latitude is increased. Therefore this Difference found, 34 deg. 30 min. is to be added to the known Latitude, 15 deg. 30 min. and they both make 50 degrees just: Therefore the Latitude of the place you are in, is 50 degrees of North Latitude.

If the place you went from had been the *Lizard*, in 50 degrees of Latitude, and you sail from thence more Southwards upon the point 58 degr. 21 min. from the Meridian Westwards,

wards, and on this Courſe have ſailed 65 deg. 46 min. and ſo found, that you have altered your Latitude 34 degr. 30 min. and are come to a place of unknown Latitude. In this caſe, becauſe the Courſe is Southerly (the Latitude of the place you are in, is leſſe than that you came from) you muſt take the Difference of Latitude found 34 degr. 30 min. from 50 deg. the Latitude known, the Remainder is 15 deg. 30 min. The Latitude of the place you are in.

PROBLEM. VIII.

The Latitude of the place you are in, and the Latitude of the place you went from, with the Rumb being given; to find the Difference of Longitude.

LEt the two places be, one the *Lizard* in the Latitude of 50 degrees, from whence you go, and the other place St. *Chriſtophers*, in the Latitude of 15 deg. 30 min. and the Rumb 58 deg. 21 min. from the Meridian, and the thing deſired is the Difference of Longitude.

Firſt, by the ſecond Problem, find out the Meridional Difference, 42 deg. 12 min. which had; Set the Tangent of the Rumb, 58 degr. 21 min. on the firſt, to the Radius on the ſecond; and then upon the Line of Numbers, againſt 42 deg. 12 min. on the firſt, is 68 deg. 30 min.

30 min. on the second. Wherefore 68 deg. 30 min. is the Difference of Longitude betwixt your two places, the *Lizard* and St. *Christophers*.

And if the place you came from, be in the Latitude of 50 degrees, and of that you are in, be 52 deg. 30 min. and the Rumb you have come upon, be the fifth from the Meridian, and you desire the Difference of Longitude. Then,

Set 56 deg. 15 min. the Tangent of the fifth Rumb on the first, to the Radius on the second, and then upon the Line of Numbers, against 2 deg. 30 min. the Meridional Difference of Latitudes on the first, is 3 deg. 45 min. on the second. So much is the Difference of Longitude desired according to the projection of the common Sea-Chart.

PROBLEM. IX.

In any Parallel of Latitude, to find out how many leagues answer to one degree of Longitude in that Parallel.

THis Problem is grounded upon this Analogie.

As the Radius, is to the Co-sine of the Latitude; So is the number of leagues, in one Equinoctial degree, to the number of leagues answering to one degree in that Latitude.

Example.

Example. In the Latitude of 18 deg. 12 min. I demand how many leagues ſailing along in that Parallel, will alter the Longitude one degree?

For Anſwer, to my deſire, I ſet the Radius on the firſt, to 71 deg. 48 min. the Co-ſine of the Latitude on the ſecond; and then on the Line of Numbers, againſt 20 on the firſt, the number of leagues in our equinoctial degree, I ſee 19 on the ſecond: And therefore every 19 leagues ſailing along in that Parallel, altereth the Longitude one degree: And on the contrary, for every degree that you alter your Longitude, you ſail 19 leagues in that Parallel.

2 In the Latitude of 51 degrees 32 minutes, it is demanded, How many leagues in that Parallel, do anſwer to one degree of Longitude?

Set the Radius on the firſt, to 38 degr. 28 min. the Co-ſine of the Latitude on the ſecond; and then on the Line of Numbers, againſt 20 on the firſt, is 12 and 4 tenths on the ſecond. So many leagues ſailing in that Parallel of 15 degr. 30 min. altereth the Longitude one degree.

If you would know how many miles alter one degree of Longitude in any Parallel.

Then,

Set the Radius on the firſt, to 38 degr. 28 min.

28 min. the Co-sine of the latitude on the second; and then on the lines of Numbers, against 60 on the first, is 37 and about one third which is 37 miles, and one third of a mile, to make one degree of longitude in that Parallel of latitude. And contrariwise, if you find you have altered your longitude one degree, you are then removed 37 miles, and about one third of a mile.

PROBLEM. X.

To find how many miles answer to many degrees of Longitude in any parallel.

Suppose you should sail along in the Parallel of 50 degrees, until you have altered your longitude 35 degrees, and then would know how many miles you have sailed.

First, reduce 35 Equinoctial degrees into minutes, by multiplying them by 60, and they make 2100 minutes. Then,

Set the Radius on the first, to 40 degr. the Co-sine of the latitude on the second; and then against 2100, the Difference of longitude in minutes, upon the first on the line of Numbers, is 1350 on the second. So many miles answer to 35 degrees, in that Parallel.

But if you would know how many leagues you have sailed, in altering your longitude 35 degrees,

degrees, then reduce the 35 degr. into leagues by multiplying them by 20, & they make 700. Now, Set the Radius to 40 degrees, as afore, & then right against 700, in the line of Numbers on the first, is 45 ● on the second. So many leagues you have sailed.

PROBLEM. XI.

Upon any Rumb proposed, to find how many leagues do answer to one degree of latitude in the Meridian, or of any great circle.

THis Problem is resolved by this Analogie.

As the Co sine of the Rumb from the Meridian, is to the Radius;

So is 20 leagues, the measure of one degree in any great circle, To the leagues that answer to one degree upon that Rumb.

Example. Suppose you sail upon the fourth Rumb from the Meridian, which is the point of Northeast, or Northwest; or else the point Southeast, or Southwest, and desire to know upon that Rumb, how many leagues do answer to one degree of the Meridian, or alter the latitude one degree.

Set 45 degrees the Co-sine of the Rumb on the first, to the Radius on the second; and then on the line of Numbers, against 20, the number

number of leagues in a degree of a great circle on the first, is 28 and almost an half. Therefore 28 leagues and an half, make one degree, or alter the Latitude one degree, in sailing upon that Rumb.

If you desire to know how many miles sailing on any Rumb, alter the Latitude one degree, as here in this Example of the fourth Rumb; then set 45 degrees the Co-sine of the Rumb on the first, to the Radius on the second; and then on the lines of Numbers, against 60 on the first, is 85 & something above on the third. So many miles, on that fourth Rumb, altereth one degree of Latitude.

I am now in the middest of the Sea, where if I should sail through all particulars; that my Instrument is capeable of, I should with my travel fill a great Volume, I will therefore leave off wading any further in this Subject, and leave the rest to the ingenuous Practioners in Navigation, to whom I wish prosperity in all their honest and laudable undertakings.

CHAP.

CHAP. XIII.

The Use of the double Scales of Sines and Tangents on the Instrument, in Dialling.

PROBLEM. I.

To find the distance of the hours from the Line of twelve a clock, Horizontal Dials, made for an oblique Sphere.

LEt an Horizontal Dial be propounded, to be drawn for the elevation of the Pole 51 deg. 30 min. For making whereof the Analogie standeth thus:

As the Radius, is to the Sine of the Elevation:

So is the Tangent of the hours in a right Sphere from 12, To the Tangent of the same hours from the line of 12, in the oblique Sphere propounded. Therefore,

Set the Radius on the first, to the Sine of the Elevation given, *viz.* to 51 deg. 30 min. on the second; and then the Instrument unremoved, against 15 deg. the Tangent of an Equinoctial hour on the first, is 11 degr. 51 min. the Tangent of one hours distance from the line of 12 a clock

a clock in the oblique Sphere of 51 degr. 30 min. and againſt 30 degrees on the firſt, being the diſtance of two Equinoctial hours, is 24 deg. 19 min. on the ſecond, for the diſtance of two hours from the line of 12, in that given latitude. And likewiſe, againſt the Tangent of 45 degrees on the firſt, the diſtance of three Equinoctial hours, in a right Sphere on that firſt, is the Tangent of 28 degr. 3 min. on the ſecond, for the diſtance of the hours of 3 and 9 a clock, from the hour line of 12, in that given latitude.

But now for the fourth and fifth hours, becauſe the Tangents of thoſe hours be above 45 degrees, you muſt work backwards in this manner: The Inſtrument nor ſtirred, look 60 degrees, the equall diſtance of the fourth hour, in a right Sphere on the ſecond; and then againſt that Tangent of 60 degrees on that ſecond, is the Tangent 53 degr. 35 min. on the firſt, for the hours of four and eight; and alſo againſt the Tangent of 75 degrees, the fifth equal hour on that ſecond, is the Tangent 71 degr. 6 min. on the firſt, for the hours of 5 in the fore-noon, and 7 after noon: As for the hours of 6 and 6, they are at juſt 90 deg. from the hour-line of 12 a clock, and ſo for any other latitude: for the hours of 5 and 4 in the morning, they are equally diſtant from the

hour

hour of 6, as is 7 and 8 ; and ſo in the afternoon, the hours of 7 and 8 are equally diſtant from 6, as is 5 and 4. By the ſame rule ſhall you find half hours and quarters, as when you would have the true diſtance of one hour and an half from the noon-line, then work by the Tangent of 22 degr. 30 min. and in ſo doing, you ſhall have 17 degr. 38 min. to be the diſtance of one hour and an half from the noon-line, in the Latitude of 51 deg. 30 min. and ſo for any other.

PROBLEM. II.

A Dial being made, and the Elevation for which it was made not being known; to find for what Latitude it is made.

FIrſt of all, get the diſtance between the hours of 12 and 1, which had, Set the Tangent of 15 deg. on the firſt, to the Tangent of that diſtance on the ſecond; and then againſt the Radius on the firſt, is the Sine of the Elevation ſought for on the ſecond.

Example. There is an old Dial, which doth appear to be a good one, and I deſire to know for what Latitude it was made, as alſo whether it be true made, or not; which to do, I firſt ſeek the diſtance betwixt 12 and 1, and find it 11 degr. 51 min. Therefore I ſet the Tangent of

of 15 degrees on the first, to the Tangent of that distance, 11 deg. 51 min. on the second; and then against the Radius on the first, is the Sine 51 degr. 30 min. on the second: Whereupon I conclude, that the Dial was made for the Elevation of 51 degr. 30 min. Thus may you examine any Dial, whether it be truely made, or not.

PROBLEM. III.

To find the distances of the hour-lines, from the line of 12 *a clock in a direct South Dial, for any Elevation propounded.*

IN the Latitude of 51 degr. 30 min. a Dial is to be made, wherein to find the distance of the hour-lines from the line of 12 a clock.

Say as in the first Problem,

As the Radius, To the Co-sine of the Poles Elevation;

So is the Tangent of any hour given, To the Tangent of the hour-line from the Meridian, Therefore,

Set the Radius on the first, to 38 degr. 30 min. the Co-sine of the Latitude on the second; and then against the Tangent of 15 deg. on the first, is the Tangent of 9 degr. 28 min. on the second, for the hours of 1 and 11; and against 30 degr. on the first, is the Tangent 19 deg.

19 deg. 46 min on the second, the distance of the hours of 2 and 10, from the line of 12. And against the Tangent 45 on the first, is the Tangent 31 deg. 54 min. on the second, for the distance of the hour-lines of 9 and 3, from the line of 12. And now backwards, against the Tangent of 60 deg. on the second, is 47 degr. 10 min. on the first, the Tangent of the distances of the hour-lines of 4 and 8, from the line of 12. And lastly, against 75 degr. on the second, is 66 deg. 43 min. on the first, the Tangent of the distance of the hour-lines of 7 and 5, from the line of 12. For the hours of 6 and 6, they make right angles with the Meridian.

PROBLEM. IV.

In a vertical Dial inclining, having the Elevation of the Pole above the Plane; to find the distance of the hour lines from the hour-line of 12 *a clock.*

LEt such a Plane be propounded, whose North part is elevated above the Horizon 16 deg. 30 min. which taken from the Elevation of the place 51 degr. 30 min. leaveth 35, degrees, for the Elevation of the Pole above the Dials Plane: Wherefore to find the distance of the hour-lines in such a Dial from the Meridian, or hour-line of 12. Say,

As the Radius, Is to the Sine of the Elevation above the Plane;

So is the Tangent of any Equinoctial hour, To the distance of the same hour-line from the Meridian, Therefore,

Set the Radius on the first, to 35 degrees, the Sine of the Poles Elevation above the Dials Plane; and then against the Tangent of 15 degrees, which is the Tangent of one Equinoctial hour on the first, is 8 degr. 45 min. on the second, the Tangent of the distance of the hours of 1 and 11, from the hour-line of 12: and against 30 degr. on the first, is 18 degr. 9 min. on the second, for the hours of 2 and 10. And for the rest of the hours, you shall have them, as you had those in the former Dials.

PROBLEM. V.

In any erect declining Dial, to find the distance of the Styll from the Substyl; and of the Substyll from the Meridian.

IN the Latitude of 52 degr. I would make a Dial to a wall, declining from the true South point 45 deg. wherein first to find the distance of the Styll from the Substyll, the work is thus:

As the Radius, To 45 degr. the Co-sine of the declination of the Dials Plane from the true South point.

So

So is 38 degr. the Co-sine of the Latitude,
To 25 degr. 48 min. the distance of the
Styll from the Substyll. Therefore,

Set the Radius on the first, to 45 degr. the Co-sine of the Declination on the second; and then against 38 degr. the Co-sine of the Latitude on the first, is 25 degr 48 min. on the second. So much is the distance of the Styll from the Substyll, or height of the Styll.

Or set the Radius to 38 deg. and then against 45 deg. is 25 deg. 48 min.

And then for the distance of the Substyll from the Meridian, this is the Rule.

Take 64 degr. 12 min. the Co-sine of that 25 degr. 48 min. the distance found, and 52 degr. the Latitude of the place, and count the greater of them two Sines for the first term in the rule of Proportion, and the lesser of them for the second term, and the Radius for the third term. And then,

Set the Sine 64 degr. 12 min. on the first, (which is the Co-sine of that sine afore found) to the Radius on the second; and then against 52 degrees, the Latitude of the place on the first, is 61 degr. 5 min. on the second, whose Complement is 28 deg. 55 min. So much is the distance of the Substill from the Meridian, in such a declining Dial. And so of any other.

But I see by my Dial, that the Sun is declined from the Meridian far into the west, casting his shadow at half an hour past six a clock after noon, and Saturday night, *August* the first 1657, time to leave work. And for as much as my occasions call me another way for the next week, and for many weeks after, I must leave off proceeding any further in this Subject of Dialling.

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